LIBRARIES

TO WHICH THE DUBLIN QUARTERLY JOURNAL OF SCIENCE IS FORWARDED GRATIS.

SWEDEN AND NORWAY.

Lund.—Kongliga Universitetet.
Stockholm.—Riksbiblioteket.
Upsala.—Kongliga Universitetet.
Christiania.—Kongelige Norske Universitet.

DENMARK.

Kjöbenhavn (Copenhagen).—Kongelige Bibliothek.

RUSSIA.

Dorpat.—Université.
Helsingfors.—Université.
Kasan.—Imper. Kazanskii Universitet.
Kharkow.—Université.
Kiew.—Université.
Odessa.—Bibliothèque Publique.
Orenburg.—Bibliothèque Publique.
St. Petersburg.—Kais. öffentliche Bibliothek.

HOLLAND.

Amsterdam.—Stadsch-Bibliotheek.
Arnhem.—Openbare Bibliotheek.
Groningen.—Université.
Leyden.—Academia Lugduno-Batava.
Utrecht.—Academia Rheno-Trajectina.

GERMANY.

Berlin (*Prussia*).—Königliche Bibliothek.
,, Universitäts-Bibliothek.
Bonn (*Prussia*).—Universitäts-Bibliothek.
Bremen (*Hanse-Town*).—Stadt-Bibliothek.
Breslau.—Universitäts-Bibliothek.
Cassel (*Hessia*).—Kurhessische Landes Bibliothek.
Cracau (*Austria*).—Uniwersytet Krakowski.
Darmstadt (*Hessia*).—Grossherzogliche Bibliothek.
Dresden (*Saxony*).—Königliche Bibliothek.
Erlangen (*Bavaria*).—Universitäts-Bibliothek.
Freiberg (*Saxony*).—Königlich Sächsische Bergakademie.
Freiburg (*Baden*).—Universitäts-Bibliothek.

GERMANY—continued.

Giessen (*Hessia*).—Universitäts-Bibliothek.
Gottingen (*Hannover*).—Universitäts-Bibliothek.
Gotha (*Saxony*).—Herzogliche Bibliothek der Friedenstein'schen Sammlungen.
Greifswald (Eldena) (*Prussia*).—Universitäts-Bibliothek.
Halle (*Prussia*).—Universitäts-Bibliothek.
Hamburg (*Hanse-Town*).—Commerz-Bibliothek.
„ „ Stadt-Bibliothek.
Hannover (*Hannover*).—Königliche Bibliothek.
Heidelberg (*Baden*).—Universitäts-Bibliothek.
Innsbruck (*Austria*).—Universitäts-Bibliothek.
Jena (*Saxony*).—Grossherzogl. herzogl. sächs. Gesammt-Universität.
Jena (*Prussia*).—Universitäts-Bibliothek.
Karlsruhe (*Baden*).—Grossherzogliche Hofbibliothek.
Kiel (*Holstein*).—Universitäts Bibliothek.
Klagenfurt (*Austria*).—Universitäts-Bibliothek.
Leipzig (*Saxony*).—Stadt-Bibliothek.
„ „ Universitäts-Bibliothek.
Lemberg.—Biblioteka Zakladu Ossolinskich.
Marburg (*Hessia*).—Universitäts-Bibliothek.
Munchen (Munich) (*Bavaria*).—Königlich Hof- und Staats-Bibliothek.
„ „ „ Königliche Universitäts-Bibliothek.
Oldenburg (*Oldenburg*).—Grossherzogliche Bibliothek.
Olmutz (*Austria*).—K. K. Bibliothek.
Pesth (*Austria*).—Universitäts-Bibliothek.
Posen.—Bibliothéque de Kurnik.
„ Raczyinski Bibliothek.
Prag (*Austria*).—Universitäts-Bibliothek.
Rostock (*Mecklenburg*).—Universitäts-Bibliothek.
Stuttgart (*Württemberg*).—K. öffentliche Bibliothek.
Tübingen (*Württemberg*).—Universitäts-Bibliothek.
Warsau.—Biblioteka Towarzystiwa Rolnierego Krolestiwa Polskiego (Agronomical Society of Poland).
Wien (Vienna) (*Austria*).—K. K. Hofbibliothek.
„ „ „ Universitäts-Bibliothek.
Wurzburg (*Bavaria*).—Universitäts-Bibliothek.

SWITZERLAND.

Basel.—Universitäts-Bibliothek.
Bern.—Universitäts-Bibliothek.
Geneve.—Bibliothèque de la Ville.
Lausanne.—Bibliothèque Cantonale Vaudoise.
Zurich.—Universitäts-Bibliothek.

BELGIUM.

Bruxelles (Brussels).—Bibliothèque Royale de Belgique.
Gand (Ghent).—Université.
Louvain.—Université Catholique.

FRANCE.

Bordeaux.—Université de France, Acad. de Bordeaux.
Paris.—American Library.
Bibliothèque de la Ville de Paris.
Bibliothèque du Jardin des Plantes.
Bibliothèque Impériale.

ITALY.

Firenze (Florence).—Biblioteca Magliabecchiana.
Milano.—Biblioteca Brera.
Napoli (Naples).—Biblioteca Reale Borbonica.
Pisa.—University Library.
Roma.—Biblioteca Vaticana.
Venezia (Venice).—Biblioteca Marciana.

SPAIN AND PORTUGAL.

Madrid.—Biblioteca Real.
Lisboa (Lisbon).—Biblioteca Nacional.

UNITED STATES OF AMERICA.

[*To be forwarded through* HENRY STEVENS, ESQ., *Literary Agent in London of the Smithsonian Institution, No.* 4, *Trafalgar-square.*]

Alabama.—State Library.
Arkansas.—State Library.
California.—State Library.
Carolina, N.—State Library.
Carolina, S.—State Library.
Connecticut.—State Library.
Georgia.—State Library.
Illinois.—State Library.
Indiana.—State Library.
Iowa.—State Library.
Kansas.—State Library.
Kentucky.—State Library.
Louisiana.—State Library.
Maine.—State Library.
Maryland.—State Library.
Massachusetts.—State Library.
Michigan.—State Library.
Mississippi.—State Library.
Missouri.—State Library.
Nebraska.—State Library.
New Hampshire.—State Library.
New Jersey.—State Library.
New York.—State Library at Albany.
" Astor Library.
Ohio.—State Library.

UNITED STATES OF AMERICA—continued.

Pennsylvania.—State Library at Harrisburgh.
Rhode Island.—State Library.
Tennessee.—State Library.
Texas.—State Library.
Vermont.—State Library.
Virginia.—State Library at Richmond.
Washington Territory.—State Library.
Wisconsin.—State Library.

GREAT BRITAIN AND IRELAND.

Belfast.—Library of Queen's College.
Cambridge.—University Library.
Cork.—Library of Queen's College.
Dublin—Geological Society of Dublin.
Library of Trinity College.
Royal Dublin Society.
Royal Irish Academy.
Natural History Society.
Institution of Civil Engineers.
Edinburgh.—Library of Faculty of Advocates.
University Library.
Galway.—Library of Queen's College.
Glasgow.—University Library.
Liverpool.—Free Public Library, Museum, and Gallery of Art, of the Town of Liverpool.
London.—British Museum.
Library of Eton College.
Library of the Hon. the East India Company.
Library of Committee of Privy Council for Trade.
Library of Corporation of City of London.
Library of the House of Commons.
University College.
King's College.
Manchester.—Manchester Free Library and Museum.
Maynooth.—College Library.
Oxford.—Bodleian Library.
Oxford Free Library.
St. Andrew's.—University Library.
Salford.—Salford Borough Royal Museum Library.
Woolwich.—Military Academy.

COLONIES.

Melbourne.—University of Melbourne.
Sydney.—University of Sydney.
St. Helena.—Library.
Toronto.—University Library.

XI.—Polar Exploration—Antarctic and Arctic (Plates VI., VII.)

By John Locke, M.R.D.S., &c.

[Read before the Royal Dublin Society, Monday Evening, November 19, 1860.]

Franklin may be termed the pioneer of modern circumpolar exploration; for, though unsuccessful himself in the unequal contest with the difficulties of discovery in Arctic climes, the example of his singularly adventurous career, as well as the devotedness of purpose displayed in the prolonged searches after this martyr of science and his brave companions, have impressed not only fresh impetus, but a new character likewise upon the enterprises of Arctic and Antarctic travel, and given new direction to the theories of scientific observers respecting those mysterious regions, hitherto barred from human ingress by unscaled escarpments of perpetual ice.

After centuries of disheartening failure in the Northern Hemisphere, the lull of public despondency is broken by a startling call from America; and a well-known indefatigable labourer in the domain of geographical research, an honorary member of our Society, Captain Maury, Director of the Observatory at Washington, points to the Southern Hemisphere,—enumerates his reasons for the probable existence of a habitable climate far within the frozen flanks of the Antarctic Zone, and chivalrously invites the British Government to join the great republic of the West in an expedition to scale the barriers and traverse the steppes of perpetual snow, sloping downward and inward, until they immerge into regions of light airs and calms,—where the air, after having precipitated all the aqueous vapour gathered from the vast reservoir which girdles the Southern hemisphere in one unbroken sweep, ascends above the normal level of the aerial ocean, and thence ebbs back with ever-flowing tide to equatorial latitudes.

In the endeavour to illustrate this topic of such strange and absorbing interest, I request attention to two diagrams,—Plate VI. representing an approximate tracing of the supposed Antarctic Continent, and showing the steamer-track, about twelve days from Port Philip, the chief naval station of the Austral seas, to some available landing point, bight, or ravine, under shadow of the precipitous coast, whence overland parties might start upon their perilous mission of discovery; Plate VII. depicts a profile view of the atmosphere. Following the outline of the outer periphery, it will be observed, that the air, like land and water, the two other principal constituents of our planet, is unequally distributed, being piled up over the belts of tropical calms, depressed over the equatorial calms, and again depressed in graduated proportion from 40° North and South, toward the polar regions.* The fainter outer shade represents the superior atmosphere, supposed to be unaffected by meteorological change, whence no messenger comes to the earth's surface, save the transient meteorite, and refracted ray of rising or setting suns.

---

* The average pressure of the atmosphere in southern latitudes, on the square foot, is from 10 lbs. to 50 lbs. less than in northern latitudes, according to the parallel. See Maury's "Physical Geography of the Sea," Introduction to *8th Edition* (Sampson Low).

In the observations laid before the Society this evening, it is sought to group together the ascertained phenomena of exploration, both Arctic and Antarctic, so as to bring the aid of analogy and geographical symmetry to the solution of the latter question.

And, first, with respect to the elementary constituents of the soil—In the geological structure of extreme northern regions, the sedimentary strata are abundant and of vast extent;* while the constitution of Antarctic strata seems, on the contrary, as far as yet examined, entirely igneous. Even when landing on island or supposed continent has been found impracticable by the navigator, a like conformation has been inferred from data, that minds untrained in scientific investigation might be disposed to pretermit or contemn. Ross and his adventurous companions in the Erebus and Terror shot many birds in about latitude 74°; and on examining their crops, the pebbles found were invariably igneous or volcanic, thus intimating the composition at least of shoreward formations; and to show that this mode of inference is not so restricted as some might imagine, it may be stated, that in the crop of one of those birds, a specimen of the *Aptenodytes antarcticus*, a gigantic penguin, weighing 75lbs., now stuffed and in the Government collection, no less than one pound weight of pebbles was found of various kinds, and therefore probably picked up along a considerable range of coast; again, stones drawn up by the dredge, and debris transported by icebergs, were invariably of granitic or volcanic structure, as well as also all the islands on which landing has been effected down to the fifty-eighth degree of latitude, all literally lands of desolation, as Kerguelen was termed by Cook. The constitution, then, of Boreal and Austral lands is in direct contrast, and unfavourable to the hypothesis of a habitable region in the latter.

Still following the analogy of exhaustive probabilities by comparison of phenomena, we next proceed to notice currents and ice-drifts. In Arctic seas, during the brief summer, the detached bergs were observed by Parry driving north through Davis's Straits against the surface cold current steadily flowing to the south, being impelled by a warmer under-current, an offset from the Gulf-stream, as proved by thermometric soundings. We, Irishmen, know to our comfort the beneficent influence of that great river in the ocean, extending from its tepid sources in Mexican waters to all the north-western shores of the old world; for Ireland would be another Labrador only for that wondrous river. Now the warm under-current, flowing north, might imply, and partly account for, the existence of that mysterious Polynia, or open Arctic sea, so long and vainly sought. From a similar phenomenon, though in converse aspect, the probability of an open Antarctic ocean may be inferred. Wilkes, alluding to the ice-drift of the south, observes—"I should not look to a surface-current, as the motive power, that carries these immense masses of icebergs north; comparatively speaking, their great bulk is below the influence of any surface-current; and the rapid transport by means of winds is still more improbable; therefore, I conceive, we must look to an under-current as their great propeller;" "and in one trial of the deep-sea thermometer, we found the temperature beneath four degrees warmer than at the surface".* Where then can this warm under-flow have its genesis, if not in the very womb of the Antarctic, which consequently possesses a higher temperature than the engirdling waters? Indeed, the direction and breadth of the berg-drift must partially indicate the extent and nature of the shores whence it is launched, as its non-appearance indicates the probable loci of openings leading to a circumpolar ocean; for icebergs are only formed on elevated and abrupt coasts, and thence released by a lateral viscous force; or toppling sheer over by their own gravity, when their bases are eroded by deep water of comparatively high temperature, or worn away in shoal-water by the ever-dashing surf. These must be the chief detaching forces—the Arctic agents of attrition by shore-streams in the ravines and fiords during the brief summer, and expansion of water frozen in rifts or fissures, not having been noticed to any extent in these extreme southern regions, where melted snow freshets never expose the surface, and many of the ice-islands (a phenomenon almost peculiar to austral waters), dotting all the offings with their strange and fantastic forms, appear to have suffered little change since the time of Cook. Indeed, it may be, that those isolated masses possess true insular nuclei.

---

* See the "Geological Map of Arctic Lands," by Professor Haughton, F.T.C.D., appended to M'Clintock's "Voyage of the Fox, in search of Franklin."

But, admitting the value of Wilkes' testimony as to a warmer deep current flowing northward, there are two wide and well-developed superficial cold currents flowing in same direction, one towards the Cape, the other (Humboldt's current) to the Horn, where it is bifurcated, rushing to the Falklands on the east, and on the west moderating by its cooling influences the high temperature of the Chilian and Peruvian shores. Between these is interposed the normal flow of tropical waters, slowly pressing southward, and checking the advance of the main body of the great ice fleet, while the two wings sweep forward unceasingly in flying columns, until smitten progressively by the suns of warmer climates. Icebergs are often met as low as the 37th°, while in northern latitudes, they rarely advance beyond the 55th. The higher latitudes of Antarctic waters are never visited, except by the whaler and the ardent votary of discovery; the path of the merchant or emigrant is far to the northward; even marine life is sparse in certain tracts of vast extent, and the sea-bird is seldom observed flying over such lonely wastes. Truly there are deserts in the sea, as on the land. It is probable that the great openings, communicating with undiscovered central regions, lie on either side of the currents just mentioned, and which therefore may furnish an approximate index for instruction of any contemplated expedition.

---

* U. S. Expedition, vol. ii., c. 10. See, also, Sir J. C Ross, vol. i., c. 7.

Wilkes, who has mapped a more extended and continuous coast than modern navigators of other nations, only traces a broken and uncertain outline of some 1600 geographical miles. Indeed, the sum total of all the discovered coasts* do not amount to one-fourth of the circumference of the sphere, measured on the mean parallel of the several latitudes; while in a considerably higher Arctic latitude the sphere has been traversed round, and coast lines traced of unexplored regions, with only exception of the northern shores of the vast continental promontory of Greenland, along the precipitous shores of which an available path to the Polynia may yet be discovered. Again, the contrast between the limits of organic life in Arctic and Antarctic zones is very remarkable and significant. Vegetables and land animals are found at nearly 80° in the northern, while from the parallel of 58° in the southern hemisphere, the lichen, and such like plants only, clothe the rocks;† and sea birds and the cetaceous tribes alone are seen upon the desolate beaches. In Boreal climes, too, there is a strong probability, which Austral regions do not furnish, of the existence of herbaceous soils in latitudes yet intact, from the fact of migration of ruminating animals, their unerring instinct leading them to lands prolific in vegetable organisms. M'Clintock‡ describes herds of rein-deer, "a perfect forest of antlers," moving north in the summer: and it is an important fact to bear in mind, that in certain high latitudes, where the summer is short yet comparatively warm, vegetable life is more abundant than in lower latitudes, where the mean annual temperature is much higher, but the summer not so warm, and seasonal changes less distinctly marked. The eider duck and brent goose through the air, the unwieldy family of the cetacea through the waters, the Arctic bear upon the ice, the musk ox and rein-deer along the land—all wend their way northward at certain seasons; suggesting the existence of a milder circumpolar climate, and consequently of open seas; for, as a general rule, isothermals are concurrent with the ocean bends.§ Now these indications are absent from the southern zone, as is also the inhabitation of man; M'Clintock‖ stating, that the bones of musk-oxen killed by the Esquimaux were found north of 79th parallel; while in the southern hemisphere man is not found above the 56th parallel of latitude.

---

* *Vide* Plate VI. Also, U. S. Expedition, vol. ii., c. 10, and charts affixed to the work.

† The vegetable kingdom has few representatives in the Antarctic. On the South Georgias, in same latitude as Yorkshire in our hemisphere, Cook did not find "a shrub big enough to make a toothpick." The South Shetlands, occupying a corresponding latitude to their namesakes in the North, present scarcely a vestige of vegetation. Kerguelen, as low as latitude 50° south, boasts 18 species of plants, of which only one, a peculiar kind of cabbage, has been found useful, in cases of scurvy; while Iceland, 15° degrees nearer to the pole in our hemisphere, boasts 870 species.—J. J.

‡ "Voyage of the Fox," c. 2.

§ "Isothermal Maps of South Pacific Ocean" have not yet been issued by Maury in his series of charts.

‖ "Voyage of the Fox," c. 2.

But, descending from higher organisms to minute forms of life, so extensively developed both in southern and northern high latitudes, Ross records a circumstance, curiously suggestive of the probability of a temperate ocean, and islands of low elevation, within the icy barriers of the south. In about latitude 74°, Coulman Island in sight, the dredge brought up from 300 fathoms, and sundry less depths, delicate specimens of the living coral.* Now naturalists are generally agreed, that this insect is incapable of working at great depths; and these corallines, being found in their living state, must have been but recently severed from the reef, and wafted (we may suppose) by the warm currents, before mentioned, from islands of comparatively mild temperature, situate within the circumpolar spaces.

There is one other class of phenomena peculiar to Austral, as distinguished from Boreal climates, which has led Captain Maury to infer the existence of a temperate clime within the icy escarpments of the Antarctic coasts. It has been long remarked by mariners, that the mean position of the barometer in Austral seas is considerably lower than in other parts of the world; and Ross observes, that "the cause of the atmospheric pressure being so very much less in the southern than in the northern hemisphere remains yet to be determined."† Mary Somerville estimates this differential quantity as equivalent to an elevation above the sea-level of 800 feet. Since 1853, observations, exceeding 100,000 in number, furnished chiefly by the logs of English, Dutch, and American navigators to the Observatory at Washington, U. S., and diligently investigated and tabulated by Captain Maury, have corroborated this curious phenomenon; from which he infers, with that ardent imaginative faculty, so often anticipative of actual discovery, that there exists a temperate region shut up behind the barrier of the Austral snows. The case may be briefly stated; still sustaining the analogy between Arctic and Antarctic zones, and assuming a question, not yet however absolutely determined,—the exactitude of relations between barometric pressure and the weather. The barometer, generally speaking, stands highest in the dry, lowest in the wet season; but in high southern latitudes it has no months of high range, and is low all the year; so that the meteorological condition of the southern is more stable than that of the northern hemisphere. In other words, there are more frequent alternations of wind, calm, fog, thunder-storm, and especially more rain, in the latter case,—notwithstanding the proportion of land to water in the north being one-half, in the south only one-eighth; so that there is four times as much water in the southern hemisphere. Now this so vastly larger evaporative expanse, on which the atmosphere rests, and in the higher latitudes as on a *continuous* engirdling base, must necessarily exhale more aqueous vapour than the equally divided land and water of the northern hemisphere; and yet the comparative phenomena of precipitation imply the contrary, as you will perceive by consulting Maury's or Johnston's rain-charts.* What, then, becomes of the excess? for the forces of evaporation and precipitation must be equal, and mutually balanced in the meteorological machinery of the wide embracing atmosphere, the universal carrier of water, as well as of light and heat, over the globe. The diminished barometric pressure in the southern hemisphere plainly declares a fact, that the test of the rain-gauge appears to deny—*i. e.*, the excess of aqueous vapour, which is one-third lighter than common air; and Maury conjectures, that this vapour must be borne within the Antarctic circle by the winds, which blow almost unceasingly towards the pole from above the 50th parallel.† These surcharged aërial currents, passing over vast desolate steppes of perpetual congelation, are reduced to an extreme degree of cold; then, being robbed of their aqueous vapour by precipitation, they receive, as sensible, the latent heat thereof; and, being further subjected to the pressure of the superincumbent atmosphere in far-removed Antarctic regions, absorb thereby a further accession of warmth, so as to produce an intern climate of comparatively mild temperature. This ingenious theory may fairly stand unquestioned, until the anomaly is reconciled by some more probable hypothesis. I am aware of the theories of Herschel and others, explanatory of the causes of the greater precipitation in the northern hemisphere; but these do not adequately account for the entire excess of evaporation in the south, especially in the region of the counter-trades. It is probable, if the Arctic pole is ever reached, that we shall find a barometric depression there also, a region of rain and mists, and a mild climate proceeding from similar causes; though such depression may be considerably less than at the Antarctic pole.‡

---

* J. C. Ross, vol. i., c. 7. See also Wilkes, U. S. Expedition, vol. ii., c. 10.

† J. C. Ross, vol. ii., c. 8 and c. 13. See also Maury's "Sailing Directions" vol. p. 446, Ed. 1859; and Somerville's "Physical Sciences," Sect. 15, 9th Edition.

The probable approaches to, and nature of, the circumpolar spaces, may fitly form the next division of inferential inquiry. By actual experience, we are less acquainted with their distinctive features, than with those of some of the celestial bodies. Indeed, to an observer in the moon, the configuration would be distinctly patent of those regions, that seem barred from our exploration by unsurmounted zones of cold. The 78th parallel of southern latitude has been reached by Ross, but no distinctly-developed oceanic passages through the icy annulus have been yet discovered; while the Arctic basin discloses the great outlets of Baffin, and the Hudson and Greenland seas; and Kane, in his sledge-expedition, reports an open sea at 82°, with a temperature of 36°, and seals and water-fowl sporting on the surface.

---

* The Rain-gauge gives 37 inches in North Temperate, only 26 in South Temperate Zone, annually.—Johnston.

† Letter to Lord Wrottesley, read before the "British Association," Session of 1860.

‡ Mary Somerville states another ground for supposition of a mild circumpolar Arctic climate:—"The pole of the earth's rotation is nearly midway between the two poles of maximum cold (one 79° latitude, 120° E. longitude, and the other near Melville Island), and a line joining these two points nearly coincides with the bisection of the polar basin, through its two great outlets, into the Pacific and Atlantic oceans—a feature strongly indicative of the absence of land, and of a milder climate, in the polar ocean."—"Physical Sciences," Section xxv., 9*th Edition.*

The poles of maximum cold in the southern hemisphere not ascertained.

Another significant fact indicative of a mild polar climate is, that the warmer winds of extreme northern regions blow from N. and N. E.,—suggesting the probability that the heated air of the Torrid Zone, ascending, flows to the Pole; whence, after precipitating its moisture, it ebbs in refluent currents through the lower atmosphere; and a similar conjecture may apply to the Antarctic question also.—J. L.

On comparing the extent of the unexplored regions, we find the Antarctic area to be nearly twice the size of Europe; whereas the unexplored Arctic area is scarcely as large as Europe. Within such vast spaces, there is ample room for many and various climes and climates.

That the unknown Antarctic is of continental form, as some conjecture, from the circumstance of land being generally antipodal to water, does not follow even on this admission; for the nature of the intra-Arctic region is not yet known; besides, an unvaried terrene area must cause a climate of perpetual congelation, where the annual increments of snow and ice would so enormously exceed the decrement from evaporation alone, that, in as few score years as Adhèmar's theory estimates thousands, the oblateness of the sphere at the pole would be transformed into a cone of such immense dimensions and gravity, as to displace the centre of gravitation, and evagate the axis of the globe;* so that the Austral ocean would be poured in one wide whelming deluge over all the inhabited globe. But the earth has remained stable for 4,000 years; and each time the rainbow spans the sky, we are reminded of the Divine assurance, that "the waters shall no more become a flood to destroy the earth." The intra-Antarctic area, therefore, is not a continent; neither is its conformation that of a mediterranean ocean, zoned with a lofty cincture of snow-clad mountains, like a vast atoll, with its central lagune sea; for that would be contrary to all analogies of geographical contour, and, besides, must eventuate in periodical cataclysms or overflows, such as have never occurred in the history of telluric revolutions. Similar inferences are applicable to the inter-Arctic area; and it is therefore conjectured, that both are archipelagoic in character†—water bearing larger proportion to land in the Antarctic than in the Arctic regions, in order to compensate by a consequent milder climatical constitution for the eight days longer winter, and so sustain the sphere unchanged in its balanced gravity, temperature, and motions. Captain Maury argues for the continental formation of the Antarctic regions, which also he supposes to abound in lofty mountains and volcanoes, so as to account for the excessive precipitation; but then such a configuration cannot co-exist with a mild climate.

---

* I have read somewhere a singular Chinese tradition of the north star having sunk suddenly towards the horizon, at a period coincident with our era of the Noachic deluge. A tilting upwards of the earth's axis would account for such a phenomenon, and for the consequent overflow of the boreal seas.—J. L.

† "There do not appear to be sufficient grounds to justify the assertion, that the various patches of land discovered by American, French, and English navigators, on the verge of the Antarctic circle, form a great southern continent. The boundary of the largest, Terre Adelie, has not been traced more than 300 miles; Enderby's Land, not exceeding 200 miles; the others being mostly of inconsiderable extent, and of somewhat uncertain determination, with wide channels between; which leads rather to the conclusion, that they form a chain of islands."—J. C. Ross, vol. i., c. 9. See, also, Plate VI.

The probability once admitted, that these regions are habitable, imagination leaps instantly to the conclusion, that they teem with organic life, animal and vegetable—the sphere of Antarctic being, so long isolated from the plastic domination of civilized man, presenting, it may be, the strange and monstrous features of some former geological era, analogous to the Fauna and Flora of Australia and New Zealand. Thence to the savage biped, unfledged, is but an easy step.—Occasionally, though at long intervals, polar seas appear to undergo a thorough break-up in some unusually warm summer, and from other unexplained causes; for instance, in 1832 the Austral waters were covered with such a vast fleet of bergs—many of them literally glaciers afloat—that the navigation round the Horn was interrupted, and mariners were obliged to put back to Valparaiso and the River Plate. At such a conjuncture, an islander, in his canoe, being drifted through the opened sluices to intern climes, involves no stranger improbabilities than the peopling of the islands of the Pacific, many of which are separated by distances of 5000 miles; and yet the inhabitants, in form, habits, and especially in structure of language, present a certain identity of type, betokening unity of origin.* What these Antœcians of the Esquimaux are like, it is vain to conjecture—whether enveloped in skins, like their Arctic congeners, or thatched, like some of the Chinese tribes; but probably the adventurous navigator, who first stumbles on them, will not be more astonished than Gunbiorn was, 900 years ago, at the outlandish Esquimaux, or than Columbus, five centuries later, when the lithe and feather-crowned Charib beckoned his dispirited crews to the pleasant shores of Guanahani. Doubtless, we shall be hearty in congratulating the successful explorer on his safe return, and curious to hear his report, though not having the least desire ourselves to make such frigid acquaintances. And, should our gracious monarch ever be proclaimed Queen of the Terra Antarctica, I most devoutly trust, that no persuasion of her Majesty's ministers, nor loyal addresses from her Antarctic subjects, will induce her Majesty, or any of the royal Princes, to visit that remotest portion of "the outer Britannic Empire."

I thank you for tolerating these playful allusions; and yet they are not unimportant, even in their very lightness, if they lead our reflections to the consideration, to which I would, in conclusion, solicit your kind attention—*namely*, What advantages, scientific, commercial, social, are legitimately to be expected from the accomplishment of the daring feat—hitherto vainly attempted, sometimes disastrously defeated—of overpassing these icy barriers, and penetrating to the poles of our planet?†

---

* "Cook's Voyages"—Appendix.

† The inquirer is referred to Maury's sanguine views of an Antarctic Expedition, sections, 876–8, &c., &c., 8*th Edition* of "The Physical Geography of the Sea" (publisher, Sampson Low). The proof-sheets (kindly furnished to me some weeks before

The chief scientific objects to be expected from polar researches—omitting all vague guesses at matters unknown to experience—are connected with astronomy, magnetism, and the geographical features of the oblate sphere.* To look upon the summer sun steadfast above the horizon, and during the long night of winter to gaze upon the moveless firmament, from a position unaffected by the diurnal rotation of the globe—and that there is such a spot, is mathematically certain—present a vantage-ground of observation, involving many curious additions to human knowledge, respecting the movements and phases of the planets, and the libration of our satellite, the cause or causes of terrestrial magnetism, and the configuration and geological structure of the polar depressions. There the principal phenomena of time and space appear under novel conditions and aspects, and must be re-cast in broader measurements,—compelling our polar residents (who will walk the earth with a firmer tread, as the centrifugal counteraction retires towards its vanishing point) to interpret, with an extended application, the Mosaical description of "the lights that rule the day, and that rule the night."—Such appear to form the chief grounds of expectation for scientific discovery, dependent, however, on a clear sky, undimmed by those fogs and clouds which are supposed to hang continuously over polar climes. Without a clear sky, the astronomer's occupation is gone; and those who dwell under an ever-impending mist cannot behold the starry sphere in its unshrouded glory.

As for commercial benefits, the intra-Antarctic seas, even if found practicable for navigation, do not lie in the direction of any desiderated track; and the Arctic passage is little thought of, since steam and the great circle routes† have bridged the many-termed ocean; and given winds, and waves, and currents, previously the terror and obstacles of the mariner, to be his chosen allies, and faithful ministrants of his will. Again, the existing trade, and its possible extension in these extreme latitudes, may be enumerated in three divisions—the peltry trade, products of the Whale and Seal tribes, and the metals and coal. As to the first, the fur-bearing land animals, not found at all in the Antarctic,

---

publication) were read to the meeting, before I presumed to express dissent from some of Captain Maury's conclusions. This enlarged edition is probably the most interesting scientific work ever published,—displaying vast and varied stores of knowledge, gathered with unparalleled industry, and clothed in language of the richest poetic structure.—J.L.

* Galileo states in his Dialogo, "that the parallelism of the earths's axis is maintained by a centre of magnetic attraction existing in space." But, whether this mysterious power has its source in the sun, or within the womb of starry distances, science must wait long to determine.—J. L.

Alexander V. Humboldt quotes a curious instance of morbid imagination (Kosmos, vol. i., 161)—"Near the North Pole, in 82° latitude, an enormous opening is imagined, from which the polar light, visible in auroras, streams forth, and by which a descent into the hollow sphere may be made. Sir H. Davy and myself were repeatedly invited by Captain Symmes to undertake this subterranean expedition."

† Maury's "Physical Geography of the Sea," c. 18.

decrease northward in high Arctic latitudes; and if the Greenland Whale and his congener of the Austral Oceans* were tracked to their breeding-places, which are conjectured to be situate in the remote polar recesses, guarded by nature from human intrusion by the encircling icy ramparts, I verily believe, that whole division of the cetaceous family would soon become extinct under the insatiable cupidity of the trader; for the only never-failing method of destruction is to harpoon the cub, the vehement love of offspring inherent in the whale rendering it then an easy prey. The loss of cetaceous products might perhaps be repaired by increased supplies of vegetable oils and ligneous fibre; but what remedies could be applied to the injurious effects in the economy of ocean life and salubrity, resulting from the extinction of the animal itself? As to the third branch of productions; copper and coal exist in abundance in the Arctic regions, but hitherto the risk and cost of procurement and transport have precluded appropriation to commercial uses;† even the reduction of auriferous substrata in many localities of northern Siberia seldom yields a profit to the miner, though he has little else to do than to quarry the frozen clods a few feet beneath the surface, and melt them, in order to obtain the pure granular metal; and how much less probability of the metals of far higher latitudes ever repaying labour and carriage!

In short, to close with a social view of the question, extreme cold on lofty elevations, or in high latitudes, appears to be the one insuperable obstacle to a complete subjugation of the earth to human service and wants; and the dwarfed stature, and mental and moral degradation, of the Fuegians in the southern, and Esquimaux in the northern hemisphere, alike attest the irrefutable conclusion, that man cannot dwell in the fulness of his attributes, nor exercise his delegated dominion over material nature, in presence of the power of extreme cold—"Who can stand before His cold"?‡ (Psalm cxlvii. 17.)

Sitting by my own fireside, I have travelled right pleasantly with Cook, Wilkes, Kane, Ross, D'Urville, and other brave adventurers, across inhospitable deserts, and through the berg-strewn oceans of austral and boreal climes; the few observations laid before the Society this evening, however inadequately reasoned, have been eliminated with diligence and care; and apparently justify the probability, that a comparatively

---

[*] These are different animals. They never cross the tropics; the warmer ocean being to them as a sea of fire.—Maury's "Physical Geography of the Sea," c. 8.

[†] No valuable mineral has yet been found, nor is any likely to be discovered, in *Antarctic* lands. In West Greenland some British mining operations have been of late years carried on with dubious success. The eastern shore ("lost Greenland"), which has been ice-blocked for centuries, if ever again reached, may afford better hopes from its more convenient geographical position. Esquimaux gossip tells of abundant mineral treasures on that coast; and Giesecké's collections in London and Edinburgh, as well as in the Museum of this Society, contain some curious, though very few valuable specimens,—practically useless, however, from not being distinctively localised.—J. L.

[‡] The original Hebrew, and the Septuagint, are emphatically expressive of the extended meaning, I have ventured to apply to this passage.—J. L.

mild climate prevails in unreached circumpolar regions, both of the southern and northern hemispheres; but that the frozen cordons, circling these central spaces, are of such extent and inclement temperature as to render ingress impracticable, and to present only to the enthusiasm of discovery "that bourne whence no traveller returns."

The conclusions (unanticipated, indeed unstudied, when my friend, Captain Maury, called my attention to the subject), to which my mind is irresistibly led, are, that all the advantages, resulting from polar travel from the earliest time to the present, are incomparably outweighed by the single enterprise (even in its partial accomplishment), of Livingstone in Africa,—that any prospective benefit, reasonably expectant on the continuance of these expeditions, are not of such value as to compensate the risk of human life, and loss of time and of material,—and that the governments of Great Britain, the United States, Holland, Russia, and France, who have hitherto embarked the pioneers of polar discovery, are not justified in affording aid or sanction to any future exploration; but that they should leave these impracticable and irreclaimable regions to the whaler, the hunter, and the zealous worshipper of science whose enthusiasm leads him to neglect the lessons of experience; conceding governmental sanction exclusively to such exploratory enterprises, as promise reproductive returns in their moral and physical consequences.

There are continents, yet scarcely known, except in isolated spots upon their geographical boundaries, and many districts of vast extent and capabilities, especially in the dominions of Great Britain, Holland, and the United States, where the scattered inhabitants are as uncultured as those deserts, in which they waste an aimless and uncertain life. Within this category lies the legitimate domain of discovery, where England and the great Western Republic—scions of the same ascendant race—may strive—I do not say in emulation, for that is too often a softer synonyme for strife, but, shoulder to shoulder, in faithful partnership, to plant the banner of Christian civilisation, and reap the harvests of climes as yet unappropriated by industrial enterprise; thus demonstrating the verity of that grand social problem—that an international federation of philanthropy and commerce constitutes the most powerful instrumentality of progress, of which humanity is capable in this our era.

Calm reflection, withdrawn from the influences of enthusiasm, deals rather with results of acts than with motives of the actors; and, while sympathising, in all respect and sincerity, with the aspirations of the brave and unselfish volunteers of discovery, I would venture to apply to the general subject of polar research the deliberate judgment, pronounced nearly a century since on the Antarctic question by a celebrated navigator, whose zeal, experience, and intrepidity have never been surpassed—"I flatter myself" (writes Captain Cook, after his last voyage), "that the southern hemisphere has been sufficiently explored, and a final end put to the searching after a southern continent, which has engrossed the attention of maritime powers for nearly two centuries, and been a favourite theory amongst the geographers of all ages." . . . .
"However, if any one should have resolution and perseverance to clear

up this point, by proceeding further than I have done, I shall not envy him the honour of the discovery; but I will be bold to say, that the world will not be profited by it".*

XII.—LETTER FROM MR. JOHN T. BAGOT, CROWN LAND COMMISSIONER, SOUTH AUSTRALIA, DESCRIBING SOME RECENT IMPORTANT DISCOVERIES IN CENTRAL AUSTRALIA.

Crown Lands' Office, Adelaide, South Australia,
October 27th, 1860.

SIR—It affords me great pleasure to be enabled to inform you that Mr. J. MacDugald Stuart, a colonist of many years' standing, formerly the companion of Captain Sturt in his spirited expedition into the interior of this colony, and since distinguished by his undaunted energy in penetrating to its hitherto unexplored regions, has, after a journey unexampled for its speed and the largeness of its results, when compared with the smallness of the means at his disposal, succeeded, not only in reaching the centre of this continent, but in solving the problem so long a matter of mere speculation, by virtually crossing the vast interior of New Holland.

Starting in April last, from "Chambers' Creek," which is situated about five hundred miles to the north of Adelaide, and is one of his own former discoveries, Mr. Stuart visited the centre of Australia, and planted a flag on the summit of a considerable range of hills, to which he gave the name of "Central Mount Sturt," thus exploding the theory so long entertained by men of the highest scientific attainments, that the centre of Australia was a depressed basin. Having accomplished this feat, he pressed forward with his little party (consisting of but two companions and himself, with thirteen horses), and boldly pushed through the vast and unknown interior, until he reached lat. 18° 57′ S. and long. 134° E., thus overlapping, by one hundred miles, the point to which Gregory had penetrated, when proceeding southwards down the Victoria River.

During the entire extent of this wonderful trip, Stuart met with fine grassy plains, well watered, and intersected by ranges of not a lofty character; the extreme distance he had to travel without water was about sixty miles.

Unfortunately for the cause of science, when our explorer had reached the latitude mentioned, viz., 18°57′, he was met by a tribe of hostile natives, who attacked him in the most savage and determined manner, and, after the exercise of great forbearance on the part of Mr. Stuart, were eventually driven off only by the loss of some of their number. On account of the smallness of his party (all the members of which had been weakened by attacks of scurvy), the gallant Stuart was at length compelled reluctantly to retrace his steps; and, with his two companions, regained in safety the abode of civilized man, much exhausted, indeed, through illness and privation, but unbroken in spirit, and ready immediately again to encounter the difficulties and dangers inseparable from such an enterprise.

---

* "Voyages," Vol. ii., c. 7.

You will see that Stuart, in this expedition, reached to within about two hundred miles of the Victoria River, and to about the same distance from the Gulf of Carpentaria. He was compelled to turn back, when in the midst of a well-watered country; and, had it not been for the overpowering attack made upon him by the natives, would assuredly have succeeded in reaching the sea-coast to the north of this colony. In the course of his expedition, Stuart discovered many curious plants; and a tree that he met with (which I believe to be the Baobab Tree) he describes as being something splendid—his whole party of three men, and thirteen horses, having rested under its shade. Mr. Stuart brought back some of the fruit, which grows in a pod, similar to that of our common bean.

Stuart's journal and map will be published in the course of a few days. In the meantime, the Government of South Australia have lost no time in fitting out an expedition of twelve men—to be provided with forty horses—that the journey so nobly commenced by Stuart may, by him, be successfully completed. I expect this party to start from Chambers' Creek in about four weeks, and that it will be the first to traverse the Australian Continent from sea to sea. The success of this exploit will, I trust, materially assist in developing the resources of this our province of South Australia, and enable us to ship our horses to India from the banks of the Victoria River. Of all advantages, however, to be derived from such a discovery as the present, the most sensible, perhaps, will be, that an overland telegraph wire can be at once run through a country abounding in timber fit for the construction of such a line; thus almost entirely obviating the difficulties and hazard of submarine communication, and establishing an intimate connexion between Old England and her remote, but flourishing, colonies in these waters. I enclose herewith a small portion of "Gelatine," brought back by Stuart on his return to Adelaide, as a specimen of the diet upon which he and his two comrades were sustained during their arduous excursion.

I have given you this rather extended statement of Stuart's journey, feeling confident that the members of the Royal Dublin Society—who ever take such a deep interest in all matters connected with the advance of geographical science—will receive with pleasure this account of a journey so perilous, so nobly conceived, and so bravely carried out. I should mention that the expedition from which Mr. Stuart has just returned was fitted out by, and at the expense of, one of our oldest colonists, Mr. James Chambers.

I am, Sir, your very obedient humble servant,

JOHN T. BAGOT.

W. E. Steele, Esq., Secretary to the Royal Dublin Society,
Kildare-Street, Dublin.

XIII.—ON SOME FURTHER APPLICATIONS OF THE FERROCYANIDE OF POTASSIUM IN CHEMICAL ANALYSIS. By EDMUND W. DAVY, A. B., M. B., M. R. I. A., Professor of Agriculture and Agricultural Chemistry in the Royal Dublin Society.

[Read before the Royal Dublin Society, December 17, 1860.]

I HAVE recently been engaged in making some experiments on the ferrocyanide of potassium, or yellow prussiate of potash, with a view to extend its applications in chemical analysis; for though this important salt has already been applied to a number of useful purposes in analytical research, still my experiments have shown me that its use might be advantageously extended, particularly as a reagent in volumetric analysis,—a form of analysis which has of late come into very general adoption, especially for technical purposes, on account of the great quickness, and at the same time accuracy, with which different substances may by its means be determined. The principles upon which volumetric analysis depend are so well known, that I need not refer to them; and, though it possesses so many advantages over the older gravimetrical method, in which the different substances are determined by weight, instead of by volume, has, however, this drawback, that the preparation of the necessary standard solutions often takes considerable time: first, in order to obtain the substance to be used for this purpose in a sufficiently pure and dry state; and, secondly, the forming a solution of it the exact strength of which may be known. For though it may appear a very simple operation to dissolve a known weight of a certain substance in a given bulk of water, or other solvent, yet where this has to be done with such great precision as is necessary in those cases, it is a tedious and troublesome operation, and any inaccuracy in the graduation of the standard solution will render all determinations made with it more or less inaccurate. It is obvious, therefore, that it would be most desirable that the substances which are intended to be used as reagents in volumetric analyses should be easily obtained in a pure state, and that when considerable time and trouble have been expended in graduating solutions of those substances, they should not be liable to undergo changes whereby their strength would be more or less altered; but that, when standard solutions have once been made, they might be kept and used for a great number of determinations.

The ferrocyanide of potassium fulfils both those conditions; for it is in general met with in commerce almost chemically pure, and in a state in which it can at once be employed as a volumetric reagent; and if at any time it should happen to occur not quite so pure, it can readily be purified by recrystallization; and, in addition to these important considerations, its solution is not prone to change, especially if it is not left exposed to the action of the light. In this latter respect it has a decided advantage over several of our most useful volumetric reagents, viz., the permanganate of potash, the protosalts of iron, sulphurous acid, &c., which, from their being so prone to undergo spontaneous decomposition, must be either freshly prepared, or the strength of their solutions be accurately ascertained every time they are used, if a day or so has elapsed between each determination.

The employment of the ferrocyanide of potassium as a volumetric reagent depends on the following circumstances, viz., that it is readily converted into the ferridcyanide of potassium (red prussiate of potash) under different circumstances, and that the point where the whole of the former salt has been changed into the latter may easily be known, either by the use of a diluted solution of a persalt of iron (which gives with a drop of the mixture a blue or green colouration, as long as any of the ferrocyanide remains unchanged), or by some other simple indication. Thus, for example, when chlorine is brought in contact with the ferrocyanide of potassium, this change, as is well known, takes place, which is expressed by the following symbols:—$2(K_2,FeCy_3) + Cl = (K_3Fe_2Cy_6) + KCl$.

The same occurs as far as the conversion of the ferrocyanide into ferridcyanide, when an acidified solution of the former salt is brought in contact with a solution of the permanganate of potash, which is instantly decolorised by the reducing action of the ferrocyanide of potassium, which is thereby converted into the ferridcyanide, and this decoloration of the permanganate continues as long as any of the ferrocyanide remains in the mixture.

Again, if a solution of the ferrocyanide of .potassium, acidified strongly with either hydrochloric or sulphuric acid, be brought in contact with a solution of the bichromate of potash, the same change of the ferrocyanide into the ferridcyanide immediately takes place.

The first reaction has been long known, and is the means employed at present for obtaining the ferridcyanide, or red prussiate of potash, for manufacturing and other purposes; the second reaction has been more recently discovered; but I am not aware that the third, in the case of the bichromate, is generally known, or that the changes which occur in the reaction have been previously studied.

From experiments which I made, it would appear that when a solution of ferrocyanide of potassium, acidified with hydrochloric acid, was mixed with one of the bichromate of potash, the following reaction was produced, viz.:—$6(K_2FeCy_3) + KO, 2CrO_3 + 7HCl = 3(K_3Fe_2Cy_6) + 4KCl + Cr_2Cl_3 + 7HO$; for, amongst other facts, I may observe, that when I mixed together solutions of the two salts in the proportions corresponding to six equivalents of the ferrocyanide of potassium to one of the bichromate of potash (as indicated in the above formula), acidifying the mixture with hydrochloric acid, I found that the whole of the ferrocyanide was converted into the ferridcyanide, and that any quantity less than that proportion of the bichromate of potash left more or less of the ferrocyanide unchanged. The same results followed the use of sulphuric acid; and it appears that a similar reaction occurs with this acid as with hydrochloric acid, with the exception that in this case the 4 equivalents of chloride of potassium and the 1 equivalent of sesqui-chloride of chromium are replaced by 4 equivalents of sulphate of potash and 1 of the sesqui-sulphate of chromium.

The proportion of either acid used, provided there is enough to strongly acidify the mixture, does not appear to affect the reaction; for I obtained precisely the same results where a very large amount of acid was employed as where the quantity necessary only to strongly acidify the mixture had been added.

On those three reactions which I have noticed may be based the means of employing the ferrocyanide of potassium in several useful determinations; the first, and one of the most important of which, is *the ascertaining the amount of available chlorine in the chloride of lime, or bleaching powder*, which is a matter of much importance in many of the chemical arts, but particularly in bleaching; for not only does the commercial value of this substance depend on the quantity of available chlorine that it contains, which is subject to great variation, from exposure to the air and other causes, but likewise it is of the greatest importance that the bleacher should readily be able to determine from time to time the strength of the bleaching liquor which he employs; for if it be too strong, he knows that the fabric which he bleaches will be injured; and if too weak, it will not be sufficiently bleached, and the process must be repeated, which incurs much additional expenditure of time.

Various methods have, from time to time, been proposed for the determination of the value of chloride of lime; but the greater number of them, from the trouble required to make the test solutions, and their not keeping when made, as well as the skill required in their use, render them inapplicable for general purposes. I shall therefore merely refer to the two methods which are chiefly used at present to determine the value of this important substance. The first is Gay Lussac's, in which the amount of chlorine is ascertained by seeing how much chloride of lime is necessary to convert a given quantity of arsenious into arsenic acid; the second is Otto's, in which protosulphate of iron is substituted for arsenious acid, and the determination of chlorine is made by seeing how much of the bleaching powder is required to change a given weight of the protosulphate of iron into a persalt of that metal; these processes are so well known, that I need not describe them.

In both these methods I find that more or less chlorine is always lost, which, however, may be reduced to a minute quantity by very carefully adding the solution of chloride of lime to that of either arsenious acid, or of protosalt of iron; but in general hands they (especially the latter process) will yield results in which too small a proportion of chlorine will be indicated, from the loss of that substance which will invariably take place.

The ferrocyanide of potassium answers admirably for the estimation of available chlorine in the chloride of lime, when used in the manner I shall presently explain, and, according to my experiments, will give in general hands far more accurate results than either Gay Lussac's or Otto's method. I am aware, however, that this salt was proposed by Mr. Mercer some years ago for this purpose; but the way which he recommended it to be used, which consisted in dissolving a certain weight of ferrocyanide in water, acidifying it, and then adding the solution of bleaching-powder from a burette, till all the ferrocyanide was converted into ferridcyanide, is I find not a good manner of employing the ferrocyanide in this estimation, and, like the other methods, will lead to a loss of chlorine; for when the solution of chloride of lime is added to the acidified ferrocyanide, a portion of the chlorine is separated, especially if the bleaching liquor be added too quickly, or is not greatly diluted. But the way I propose of using the ferrocyanide of potassium in this important valuation is to mix together a certain quantity of a standard solution of ferrocyanide with a given amount of a graduated solution of the chloride of lime, using more of the former salt than the latter can convert into ferridcyanide; then adding hydrochloric acid, to dissolve the precipitate formed, and render the mixture strongly acid; and finally ascertain, by means of a standard solution of bichromate of potash, how much of the ferrocyanide remained unconverted into the ferridcyanide by the action of the chlorine of the chloride of lime, which is effected by adding, slowly, from a graduated burette, the standard solution of bichromate till a minute drop, taken from the well-stirred mixture, by means of a glass rod, ceases to give, with a small drop of a very dilute solution of perchloride of iron, placed on a white plate, a blue or greenish colour, but produces instead a yellowish brown.* When this latter effect is observed, it indicates that all the ferrocyanide has been converted into ferridcyanide; and as 147·59 (one equivalent) of bichromate of potash is capable of converting 1267·32 (six equivalents) of crystallized ferrocyanide of potassium into ferridcyanide; and as 422·44 (two equivalents) of the ferrocyanide are converted into the same substance by 35·5 (one equivalent) of chlorine, as is seen by the formulæ already given; knowing the amount of chloride of lime employed, we have all the data necessary to calculate the per-centage of chlorine.

Having made two standard solutions, the first containing 21·122 grammes of ferrocyanide of potassium in a litre of the solution, and the second 14·759 grammes of bichromate of potash in the same quantity of solution (weights which are to each other as their atomic equivalents), I made several estimations of chloride of lime with them, adopting the method I have just described, and found that it gave the most consistent results, and which agreed very closely with those obtained by Gay Lussac's and Otto's method, when the latter were performed with the greatest care,—the only difference being, that the results obtained by my method indicated a few hundredths of a part more of chlorine than either of those methods did, which may be accounted for by the unavoidable loss of a minute quantity of chlorine which takes place in those processes.

---

* The yellowish-brown coloration, which is at first produced when enough of the bichromate has been added, quickly changes to a greenish colour by some secondary reactions, which take place when the persalt of iron is left in contact with the mixture; but this does not interfere with the test; for it is the first effect that is produced which indicates the completion of the reaction, and not the after-changes which may result.

In order to simplify the process, and render the calculation as short as possible, I would recommend, for commercial valuations, the following way of carrying out this principle:—

Having obtained a flat-bottom flask, or bottle, which will contain ten thousand grains of distilled water, when filled up to a certain mark in the neck, make two standard solutions—the first, by placing in the flask, or bottle, 1190 (or exactly 1189·97)* grains of the purest crystallized ferrocyanide of potassium (yellow prussiate of potash) reduced to powder, adding distilled water to dissolve the salt, and, when this is effected, filling up with water to the mark; and having mixed the solution thoroughly, place it in a well stoppered-bottle. The second standard solution is made in the same manner, substituting for the ferrocyanide 138·6 (or exactly 138·58) grains of bichromate of potash, which has been purified by re-crystallization, and fused in a crucible, at as low a heat as possible. Both these solutions will keep unchanged, and will answer for a number of determinations, if they are preserved in well-stoppered bottles, and the ferrocyanide solution be kept, when not in use, excluded from the light. Get a burette, or alkalimeter, capable of holding or delivering 1000 grains of distilled water, and divided into 100 equal divisions; also two small bottles, one capable of delivering 1000 grains, and the other, 500 grains of distilled water, when filled up to a certain mark on the neck of each,† which may both be readily made by filling them with water, emptying them, and, after they have drained for a minute or two, weigh into each the above weights of distilled water; or, what will be sufficiently accurate for most purposes, pour from the burette into one, 100 divisions of distilled water, and into the other 50, and mark with a file where the fluid stands in the neck of each bottle. Having these all ready, take an average specimen of chloride of lime, and weigh out 100 grains of it, and make in the usual way a solution of it, by trituration in a mortar with some water; and, pouring it into the flask which was used in preparing the two standard solutions, and having filled up with water to the mark in the neck, mix the solution thoroughly, and before each time any of the chloride of lime is taken out, shake well the contents of the flask. Measure out into a beaker glass, by means of the two little bottles, 100 divisions of the chloride of lime solution, and 50 of the standard solution of ferrocyanide; and, having mixed them well together, add some hydrochloric acid, to dissolve the precipitate formed, and acidify the mixture strongly, and having mixed the whole well, pour from the burette slowly the standard solution of bichromate (stirring well all the while) till a drop, taken from the mixture and brought in contact with a drop of a very weak solution of perchloride of iron, produces a yellowish-brown colour, as already noticed. Then read off the number of divisions of the standard solution of bichromate which was necessary to produce this effect, and this, being deducted from 50, gives the percentage by weight of chlorine.

---

* The above numbers are obtained as follows:—35·5 parts of chlorine are capable, as before stated, of converting 422·44 parts of the crystallized ferrocyanide of potassium into ferridcyanide; therefore, 100 parts of the former will convert 1189·97 parts of the latter into the same compound. Again, as before observed, 1267·32 parts of the crystallized ferrocyanide require 147·59 of the bichromate of potash to convert them into the ferridcyanide; 1189·97 parts, therefore, will take 138·58 parts of that salt to produce the same effect.

† Two small pipettes, capable of delivering the above quantities, would be found still more convenient.

For the standard solution of ferrocyanide having been made, so that the 10,000 grain-measures should be equivalent to 100 grains of chlorine, and as every division of the burette equals 10 grains, each of these divisions of the ferrocyanide solution, converted into ferridcyanide, will indicate 0·1 grain of chlorine; again, the 100 divisions of the solution of chloride of lime represent 10 grains of that substance, and we want to know how many divisions of the ferrocyanide solution its chlorine has converted into ferridcyanide? this is readily ascertained by the bichromate solution, which has been so graduated that each division represents a division of the ferrocyanide solution.

So that, to determine the percentage of chlorine, we have only to deduct, as before stated, the number of divisions of the bichromate solution employed from the 50 of the ferrocyanide solution, and the difference gives us the percentage of chlorine, by weight, in the sample; thus, in four experiments, 50 divisions of the ferrocyanide solution, mixed with 100 divisions of the solution of chloride of lime, required 18·5 divisions of the bichromate solution to convert the whole of the ferrocyanide employed into ferridcyanide; this number, taken from 50, leaves 31·5 divisions of ferrocyanide, which were converted into ferridcyanide by the chlorine of the chloride of lime; and as each division represents 0·1 grain of chlorine, 31·5 will be equivalent to 3·15 grains of chlorine, which is the amount contained in 10 grains of the sample; consequently, 100 grains will contain 31·5 grains of chlorine, which is the same amount as is obtained by simply deducting the number of divisions of bichromate solution employed from 50 of ferrocyanide used in the estimation.

Though this process appears a long one, from the details which are necessary to explain its principle, yet in practice it is very expeditious, and requires only a very few minutes for its performance, and is much quicker than either Guy Lussac's or Otto's method.

Though I have as yet chiefly confined my attention to the use of the ferrocyanide of potassium in the estimation of chlorine in bleaching powder, I have no doubt but that it may be advantageously employed in many other useful determinations, by carrying out the principles already explained; thus, for example, it may be used as a means of determining the amount of bichromate of potash present in a sample of that salt, or the quantity of chromic acid that exists under different circumstances. Again, the same salt may be used in different determinations where a certain amount of chlorine is liberated, which represents a proportional quantity of some other substance; thus, for example, in the estimation of manganese ores for commercial purposes, where they are heated with hydrochloric acid, the quantity of chlorine disengaged will indicate a certain amount of peroxide of manganese in the ore, on the presence of which its commercial value almost entirely depends; and the chlorine evolved may be estimated by absorbing the gas in a dilute solution of caustic potash, and then determining the amount of chlorine in it by precisely the same process as that I have recommended in the valuation of chloride of lime. To test the accuracy of this method, I heated in a small flask a given quantity of pure bichromate of potash with an excess of strong hydrochloric acid, and collected the evolved chlorine by means of a dilute solution of caustic potash, employing the bulbed retort and curved dropping-tube, as recommended by Bunsen in the analysis of chromates,* and ascertained afterwards by the use of the ferrocyanide of potassium the amount of chlorine evolved, which corresponded almost exactly with the calculated amount of that substance which should have been obtained by the action of the quantity of bichromate used on the hydrochloric acid. Again, a standard solution of ferrocyanide of potassium may be used, as E. de Haen has shown, to determine the strength of the permanganate of potash in the analysis of the ferrocyanide and ferridcyanide of potassium, as an acidified solution of the ferrocyanide, as before stated, rapidly decolorises a solution of permanganate of potash, whereas the ferridcyanide has no action on that salt, and this reaction might be taken advantage of in the valuation of chloride of lime, to determine the excess of ferrocyanide used in my process; but, from my experiments, I found that more precise and accurate results were obtained by the use of the bichromate of potash.

The reaction of the bichromate of potash on the ferrocyanide might be employed in the valuation of the ferrocyanide of potassium and other ferrocyanides, having previously, in the case of those which were insoluble, converted them into the ferrocyanide of potassium, by boiling them with caustic potash, and separating the insoluble oxides by filtration.

It might also be employed for the valuation of the commercial red prussiate of potash, which is now to some extent employed as a bleaching agent in calico printing, and which consists of varying quantities of ferro- and ferridcyanide of potassium, together with chloride of potassium, by ascertaining first how much a given quantity of the sample requires of a standard solution of bichromate of potash to convert the ferrocyanide present into ferridcyanide, the percentage of that substance would be known; and then, by taking another portion of the sample, and converting the ferridcyanide it contained, by reducing agents, such as the sulphite of soda and potash, &c., into the ferrocyanide, and finally determining the amount of bichromate necessary to bring the whole of the ferrocyanide then present into the state of ferridcyanide, the difference in the two results would indicate the proportion of ferridcyanide originally present in the sample.

---

* See the last edition of Fresenius's "Quantitative Analysis," p. 234.

The last application of ferrocyanide of potassium which I shall notice in the present communication, is its employment as a reducing agent. It has long been known that the cyanide of potassium possesses most powerful reducing properties, and has been very usefully employed for that purpose in the reduction of different metallic salts, under various circumstances; but I am not aware that the ferrocyanide of potassium has been proposed or used for similar purposes; at least, I have referred to a great number of analytical and general chemical works, and in none of them is this salt recommended as a reducing agent, though the cyanide is so much extolled for that purpose. According to my experiments, the ferrocyanide is a far more convenient reducing agent than the cyanide, and may be substituted for it in many cases of reduction with the best effects, as it possesses many unquestionable advantages over that salt for this purpose; thus, the ferrocyanide does not deliquesce and decompose when exposed to the air, whereas the cyanide rapidly absorbs moisture, and, unless kept in very well stoppered bottles, becomes quite wet, and in this state quickly decomposes; and this deliquescence on the part of the cyanide is often a source of much inconvenience in its use as a reducing agent, owing to the almost unavoidable absorption of more or less moisture which takes place in mixing it with the substance to be reduced, and the introduction of the mixture into the reducing tube. The ferrocyanide, on the other hand, in a thoroughly dried and finely powdered state, can be intimately mixed with the substance without any appreciable absorption of moisture. I made the following comparative experiment, to ascertain the relative absorptive properties for moisture of the two salts under the same circumstances. Having thoroughly dried, in a water-oven, till it ceased to vary in weight, some finely-powdered ferrocyanide, I placed 50 grains of it in a counterpoised watch-glass, and, powdering in a warm mortar some fresh cyanide of potassium, I placed the same quantity of it in a similar counterpoised watch-glass, and left them both exposed to the air. On examining them, after four hours' exposure, I found that the former had only gained the $\frac{6}{100}$th part of a grain of moisture, whereas the latter had taken up 3·6 grains, or sixty times as much moisture, under the same circumstances. After two days' exposure, I found that nearly all the cyanide had passed into the liquid condition, having taken up 46 grains of water, whereas the ferrocyanide appeared perfectly dry, and had only absorbed 1·4 grains.

The great fusibility of the cyanide is sometimes rather a disadvantage, which has to be lessened by mixing it with a certain proportion of dried carbonate of soda; but the ferrocyanide, not fusing at so low a temperature, does not require, in most cases, this admixture to lessen its fusibility. Again, the ferrocyanide is not a poisonous salt; whereas the cyanide is highly so, and must be used with great caution; and, lastly, the former salt is little more than half the price of the latter. Combined with the above advantages, I find that the ferrocyanide is equally active in reducing metallic oxides and sulphurets, and is especially convenient for the reduction of different combinations of arsenic and mercury, which are reduced by it with the greatest ease.

I made several comparative experiments with the dried ferrocyanide and with the cyanide as reducing agents for the sulphuret of arsenic and arsenious acid, employing the same quantity of arsenical compound with each salt under similar circumstances; and in almost every case, particularly where the quantities operated on were minute, I obtained more satisfactory results with the dried ferrocyanide than with the cyanide.

The following were amongst my experiments:—

I mixed the $\frac{1}{10}$th of a grain of sulphuret of arsenic with 3 grains of the dried ferrocyanide, and made a similar experiment, substituting the same quantity of cyanide; and, on heating the mixtures in a similar glass tube, obtained almost identically fine and characteristic rings of metallic arsenic.

I then intimately mixed the same quantity of sulphuret of arsenic with 49·9 grains of very finely powdered glass, and taking 5 grains of this mixture, containing the $\frac{1}{100}$th part of a grain of the sulphuret, mixed them with 5 grains of the dried ferrocyanide, and made a comparative experiment with another 5 grains of the mixture, substituting the same quantity of cyanide. On heating both those mixtures in small reduction tubes, I got the characteristic metallic rings in both; but better defined in the case of the ferrocyanide.

I finally took 2·5 grains of the mixture of sulphuret and glass, containing about the $\frac{5}{1000}$th part of a grain of sulphuret of arsenic, and treated them in the same manner, using in one case 2·5 grains of ferrocyanide, and in the other 2·5 grains of cyanide, and obtained in each case a minute metallic ring; which, however, was much more distinct and satisfactory where the ferrocyanide had been used as the reducing agent.

The same comparative experiments were made with arsenious acid, when results similar to those in the case of the sulphuret of arsenic were obtained.

The ferrocyanide, therefore, is a most delicate reducing agent in the case of arsenical compounds; and where very minute quantities have to be detected, appears, from my experiments, to give more satisfactory results than the cyanide.

Whether the addition of dried carbonate of soda would improve the ferrocyanide for some cases of reduction, I am not at present able to say; but in one experiment which I made with the sulphuret of arsenic, I obtained equally good results, using the ferrocyanide alone, as where it was mixed previously with its own weight of dried carbonate of soda. In many cases the ferrocyanide may be used as a reducing agent in a state of powder, without separating its water of crystallization; but in most cases it will be rendered a far better reducing agent by being previously dried at 212° in a water-bath or oven, and in this dried condition it may be kept for any length of time in a good stoppered or well-corked bottle.

Though as yet my experiments have been chiefly confined to the reduction of different compounds of arsenic and mercury, I entertain no doubt that the ferrocyanide of potassium will be found an equally effective reducing agent in the case of the combinations of other metals; and that it may with great advantage be substituted for the cyanide of potassium, in many cases where the latter salt is used as a reducing substance.

XIV.—ON TWO ASSOCIATED MINERALS FROM ROSS HILL, NEAR MAUM, CO. GALWAY. By JAMES APJOHN, M. D., Professor of Chemistry and Mineralogy in the University of Dublin.

[Read before the Geological Society of Dublin, December 12, 1860.]

IN January, 1859, I received from Alexander Dickson, Esq., agent to Lord Leitrim, a box of rocks and minerals, and was requested by him to make such experiments upon them as would enable me to report upon the commercial value of each, and the mineral character of the district in which they were found. The specimens were collected by Mr. Dickson upon the townlands of Cleggan and Carrowgariffe, part of the Ross-hill estate, situate in the mountain district of Connemara, lying between Lough Mask and Lough Corrib. The metallic minerals were few in number, and of a common kind, consisting of galena, the ordinary ore of lead, and of two compounds of sulphur and iron. One of these, which occurred in minute crystals, disseminated through quartz, was the well-known iron pyrites; the other was massive, slightly magnetic, and had adhering to, and dispersed through it, a green substance, resembling chlorite, and which, upon a qualitative examination, was found to be a silicate of the protoxide of iron.

Of the earthy minerals, there was but one having any claim to novelty, and it is to this that I venture to solicit the attention of this Society for a few moments.

This substance, which Mr. Dickson informed me was very abundant on Cleggan, had a curved, foliated structure, the laminæ of which it was composed not being parallel in masses of any size, but intersecting at various angles. Its colour was white, with occasionally a tinge of yellowish-green; its lustre pearly, and in very thin laminæ it was subtranslucent; its hardness was somewhat over 2, or a little higher than gypsum.

Before the blow-pipe it was nearly infusible, and it had the specific gravity of 2·802. Submitted to a careful analysis, it was found to have the following composition:—

Silex,	46·42	1·02	4
Alumina,	37·92	0·74	3
Peroxide of iron,	0·46		
Lime,	0·67	0·26	1
Magnesia,	0·17		
Potash,	9·63		
Soda,	1·54		
Water,	4·40	0·48	2
	101·21		

Upon discussing these results in the usual manner, they are found to conduct to the empirical formula

$$4\,SiO_3 + 3R_2O_3 + RO + 2HO,$$

R_2O_3 representing the alumina and peroxide of iron, and RO the combined amount of the alkalies and alkaline earths. From this it is easy to deduce the rational formula

$$RO,\ SiO_3 + 3(R_2O_3,\ SiO_3) + 2HO\ ;$$

or, should we wish to avoid any hypothesis as to the manner in which the proximate constituents are arranged, we can write it

$$(\tfrac{1}{10}3RO + \tfrac{9}{10}R_2O_3)\ \tfrac{6}{5}SiO_3.$$

This latter method of representing in symbols the constitution of a mineral is becoming popular with mineralogists, as it takes cognizance of a fact, now pretty well established, viz., that protoxides and sesquioxides may replace each other; and also exhibits, by means of the coefficient attached to the silicic acid, the ratio between the amount of oxygen in the latter and in the basic oxides.

When I had completed this analysis, I was under the impression that I had fallen on a new and interesting mineral, having some general resemblance to talc, but differing from it in important particulars, being a little harder, and having a totally different composition,—containing, for example, but a mere trace of magnesia, the sole basic constituent of true talc, but, instead thereof, about 38 per cent. of alumina, and over 11 per cent. of mixed soda and potash. Before, however, announcing it as new, it became necessary to look into the books; and, having done so, I find mention made of several minerals which have some resemblance to that under consideration. A few of these minerals have been noticed by Thomson and Dana; but the most complete list of them occurs in the recent interesting volume, by Greg and Lettsom, on the Mineralogy of Great Britain and Ireland. The subjoined Table includes these different minerals, and, in addition, the Damourite of Delesse, a mineral found in Brittany, associated with Kyanite. The name of each mineral, its locality, and the name of the chemist by whom its analysis was made, is also given:—

TABLE I.

	Talcite, Wicklow (Tennant.)	Talcite, Wicklow (Short).	Gilbertite, Cornwall (Lehunt).	Gilbertite, Cornwall (Thomson).	Talcite, Three-Rock Mountain, Co. Dublin, (Haughton.)	Margarodite, St. Etienne (Delesse).	Margarodite, Connecticut (Brush).	Damourite, Brittany (Delesse).
Silex, ...	44·55	46·00	45·15	47·79	43·47	46·23	46·50	45·22
Alumina, . . .	33·80	35·20	40·11	32·61	31·42	33·08	33·91	37·87
Peroxide of Iron,	. .	. .	. .	. .	4·79	3·48	2·69	. .
Protoxide of Iron,	7·70	2·88	2·43	5·17	. .	. .	·82	trace
Protoxide of Manganese,. . . .	2·25	3·94	. .	. .	. .	. .	·31	trace
Lime, ...	1·30	9·61	4·17	. .	1·38	. .	. .	. .
Magnesia, . . .	3·30	. .	1·90	1·60	1·13	2·10	·90	. .
Potash, ...	. .	. .	. .	. .	10·71	8·87	7·32	11·20
Soda, ...	. .	. .	. .	9·23	1·44	1·45	2·70	. .
Water, ...	6·25	2·00	4·25	4·00	5·43	4·12	4·63	5·25
	99·15	99·63	98·01	100·40	99·77	99·33	99·78	99 54

Before comparing these minerals with each other, and with that from Connemara, it was desirable to calculate the empirical formula of each. This has been done, and the results are here subjoined:—

TABLE II.

Talcite, Wicklow (Tennant), . .	$6SiO_3 + 4R_2O_3 + 3RO + 4HO$.
Talcite, Wicklow (Short), . . .	$5SiO_3 + 3R_2O_3 + 2RO + HO$.
Gilbertite, Cornwall (Lehunt), . .	$6SiO_3 + 5R_2O_3 + 2RO + 3HO$.
Gilbertite, Cornwall (Thomson), .	$10SiO_3 + 6R_2O_3 + 5RO + 4HO$.
Margarodite, Three-Rock Mountain (Haughton), ...	$3SiO_3 + 2R_2O_3 + RO + 2HO$.
Margarodite, St. Etienne (Delesse),	$3SiO_3 + 2R_2O_3 + RO + 1{\cdot}3HO$.
Margarodite, Connecticut (Brush and Smith), ...	$3SiO_3 + 2R_2O_3 + RO + 1{\cdot}6HO$.
Damourite, Brittany (Delesse), .	$4SiO_3 + 3R_2O_3 + RO + 2HO$.
Mineral from Connemara (Apjohn),	$4SiO_3 + 3R_2O_3 + RO + 2HO$.

The preceding Table may be also thus written:—

TABLE III.

Talcite (Tennant), ...	$(\frac{1}{5}3RO + \frac{4}{5}R_2O_3)\,\frac{6}{5}SiO_3 + 4HO$.
Talcite (Short), ...	$(\frac{2}{11}3RO + \frac{9}{11}R_2O_3)\,\frac{15}{11}SiO_3 + HO$.
Gilbertite (Lehunt), ...	$(\frac{2}{17}3RO + \frac{15}{17}R_2O_3)\,\frac{18}{17}SiO_3 + 3HO$.
Gilbertite (Thomson), . . .	$(\frac{5}{23}3RO + \frac{18}{23}R_2O_3)\,\frac{30}{23}SiO_3 + 4HO$.
Margarodite (Haughton), . . .	$(\frac{1}{7}3RO + \frac{6}{7}R_2O_3)\,\frac{9}{7}SiO_3 + 1{\cdot}3HO$.
Margarodite (Delesse), . . .	Do. do.
Margarodite (Smith and Brush), .	Do. do.
Cleggan Mineral (Apjohn), . .	$(\frac{1}{10}3RO + \frac{9}{10}R_2O_3)\,\frac{6}{5}SiO_3 + 2HO$.
Damourite (Delesse), ...	Do. do.

Of these different minerals, the only one which has exactly the same composition with mine is the Damourite of Delesse. The analysis is given in Dufresnoy's Mineralogy; and upon examining it, I find it yields precisely the same formula as that at which I have arrived for the mineral from Cleggan. I may add that it has the same specific gravity (2·792), the same degree of hardness, the same colour and lustre, and behaves before the blow-pipe in a similar manner. In fact, I cannot entertain any doubt that they are both specimens of the same species.

The Wicklow Talcites, analysed by Short and Tennant, are quite distinct from my mineral, their formulæ being different, and the fixed alkalies being absent from them. The same may be said of the Cornish Gilbertites; only one of these (that analysed by Thomson) includes an alkali, and this is altogether soda. The Margarodites of Haughton, Delesse, and Brush, appear to be identical minerals; but, although including the alkalies in considerable quantity, their formulæ are so different from that of the Cleggan mineral, and from Damourite, that the two latter cannot be confounded with them. Their physical characters also are, I believe, materially different from Damourite. This is certainly true of the mineral analysed by our Chairman,—a specimen of the speckled mica of the Three-Rock Mountain,—but which Greg and Lettsom have most unjustifiably denominated *Talcite.*

And here it will be proper to observe, that our able and indefatigable President, in his valuable Notes on Irish Mines, has given the analysis of a pale-green steatitic substance, which he describes as often occurring in the mineral lodes of Wicklow, and the granite which they traverse. This mineral might certainly be called a Talcite, from its resemblance to some varieties of Talc. It is also similar in appearance to Damourite; but differs from it somewhat in composition,—not, however, to such a degree as to render it impossible that they should be the same mineral. The close analogy between the two minerals will be best seen by writing the formula of each upon the hypothesis which assumes that a protoxide and a sesquioxide can replace each other in quantities which include the same amount of oxygen. Written on this plan, the pale-green steatitic mineral of Professor Haughton, and the mineral from Connemara, will be represented as follows:—

Mineral from Connemara, . . $(\frac{1}{10}3RO + \frac{9}{10}R_2O_3)\frac{6}{5}SiO_3$.
Pale-green steatitic mineral, . $(\frac{1}{10}3RO + \frac{9}{10}R_2O_3)\frac{3}{2}SiO_3$.

The discrepancy between these formulæ is certainly small, and I incline to the opinion that the minerals to which they refer will ultimately prove to be the same; or, in other words, that Professor Haughton has preceded me in detecting the Damourite in Ireland. The locality of Cleggan, in Connemara, will still be distinguished by containing this mineral in large masses, spread over an extensive district, and not merely as a thin, superficial coating on granitic rocks, the form in which it has been found in Wicklow.

The Damourite of Delesse was, as has been already mentioned, found associated with numerous crystals of Kyanite. I have now to state that the Damourite of Connemara has imbedded in it numerous prismatic nodules, more or less rounded, of a mineral having the same composition as Kyanite, and well known under the name of Andalusite. In thin splinters, it has something of a flesh-red colour; is subtranslucent, and infusible before the blow-pipe. The crystalline form could seldom be deduced from an examination of the nodules; but in one or two specimens the outline of the right rhombic prism could be traced without difficulty. The specific gravity, taken with great care, was 2·9952, a number which may be considered as identical with 3, the latter being that usually given in systematic works as representing the density of Andalusite. This coincidence in physical characters is so complete, that it seemed almost superfluous to submit the imbedded nodules to analysis. For fear, however, of any mistake, this precaution was taken; and it was found that the experimental results corresponded sufficiently well with the formula

$3Al_2O_3$, $2SiO_3$, which is known to represent the composition of most varieties of Andalusite. Nothing more, I may observe, than an approximation to the truth could be expected; for the nodules were so coated on the surface, and penetrated throughout with flakes of the Damourite, that it was found impossible to obtain for experimental purposes specimens of perfect purity.

XV.—LETTER FROM MR. THOMAS STANLEY ON THE FAULTS SOMETIMES FOUND IN THE DRIFT GRAVEL OF IRELAND.

[Read before the Geological Society of Dublin, June 13, 1860.]

Tullamore, June 8, 1860.

SIR,—I beg to inform you that I had been occasionally upon the line of rail which runs from this town to Athlone during the time of its construction; and, while I amused myself with the gossip of holiday folks, who used to be loitering about, and all agape at the gashes in the green-hill sides, and other objects of wonder, I was not inattentive to the geological features which were presented; and drift phenomena—an old hobby of mine—could not possibly be forgotten. All the cuttings of the way were in drift deposits. Four great esker ridges were opened; one of these, which runs beside Clara, when in section, exhibited sands and gravels stratified in a very beautiful manner. While I was testing the stratification of this esker, I was greatly surprised to find the whole mass broken through with faults. The strata from the surface to the lowest sinkings were cut by perpendicular fractures; some of which were close by each other, and some were a few yards apart; and the elevations and depressions varied from two or three inches to as many feet. The direction of the break was parallel to the range of the hill. Being aware that there was another sinking in a similar pile near the Terminus in Athlone, I took the earliest opportunity to see it. I found the disturbance greater here than at Clara, the breaks being closer to each other, and more complicated. And here, while resting amongst these sands, at the end of a toilsome journey, the reward and chief object of which were lying open like a great book before me, I was not a little amused with the geology of three of Athlone's burghers. Peacock, calling to Peacock,—while I escaped being run over by them,—Why is it that these sands are always found without stones? And Peacock responding, Why, Peacock, it is because no stones are ever found in them. The disturbance evidently increases with the distance from Tullamore. There are not many breaks in strata in the neighbourhood of this town. This is probably part of an extensive disturbance which is known to have occurred in the drift. In some papers, which were addressed to your Society, I noticed the almost demonstrable fact of an ebb interval of some centuries occurring between two drifts, or overflow periods; and it is probable that our disturbance took place in this interval. Though the faults are continued upwards to the surface, they do not break the smooth outline of hill; and patches which have not known cultivation should retain a ridge and furrow, if there had not been a levelling agent. It is certain that overflows succeeded the disturbance, which removed the inequalities I noticed in clay deposits overlying the faults in some instances.

I am your obedient servant,
THOMAS STANLEY.

Professor Haughton, Trinity College, Dublin.

XVI.—ON THE GENERAL THEORY OF THE INTEGRATION OF NON-LINEAR PARTIAL DIFFERENTIAL EQUATIONS. By the REV. ROBERT CARMICHAEL, F. T. C. D.

[Read before the Royal Irish Academy, Monday, February 11, 1861.]

A COMPLETE theory of the genesis and solution of non-linear partial differential equations of the second and higher orders, in two or more independent variables, has been long a desideratum; and any considerable addition to our knowledge in this department of science can only be expected from the combined labours of those who have devoted some attention to this branch of the Integral Calculus. The following paper is intended as a small contribution towards the formation of such a theory. The solutions of non-linear partial differential equations are sought in the form of what are denominated 'complete primitives,' exhibiting arbitary constants, as contradistinguished from 'general primitives,' exhibiting arbitrary functions. It is allowed that solutions in the latter form are more general; but then they are theoretically unattainable, unless in certain cases which, the equations being linear, admit of symbolic treatment, or which are susceptible of reduction by methods not universally applicable. The importance of the subject, partly in connexion with the Calculus of Variations, and partly with the higher branches of mathematical physics, cannot well be overrated. It is well known that in the more advanced departments of mathematical physics one of the principal obstacles to our progress arises from the difficulty of integrating the partial differential equations which represent the conditions of the problem investigated; that these integrals have been sought in form of general primitives, which are in most cases unattainable; and that, if such forms of solution are attainable, a fresh difficulty arises upon our seeking to determine the forms of the arbitrary functions introduced. It is impossible now to determine what may be the physical value of the integrals of such differential equations, when stated in the form of complete primitives; but, in the default of better, such solutions may afford us, at least, *some* information. The following remarks are offered in the hope of being thus beneficial:—

1. If we are given any equation, including two arbitrary constants α, β, and two independent variables x, y,

$$f(x, y, z, \alpha, \beta) = 0, \qquad \text{(I)}$$

we may differentiate this equation with respect to the independent variables x and y, thus obtaining

$$\left(\frac{df}{dx}\right) = 0, \left(\frac{df}{dy}\right) = 0\,;$$

and, by eliminating a, β between the three equations stated, we get a partial differential equation, in general non-linear,

$$\mathrm{F}\left(x, y, z, \frac{dz}{dx}, \frac{dz}{dy}\right) = \mathrm{F}\,(x, y, z, p, q) = 0,$$

of which (I) is said to be a *complete primitive.*

2. Again if, u being any function of known form in x, y, z, we were given an equation of the type

$$f_{\prime}\,\{x, y, z, \phi\,(u)\} = 0, \tag{I$'$}$$

ϕ being any arbitrary function, we might differentiate as before, and eliminate ϕ, ϕ', thus again arriving at a partial differential equation

$$\mathrm{F}_{\prime}\left(x, y, z, \frac{dz}{dx}, \frac{dz}{dy}\right) = \mathrm{F}_{\prime}\,(x, y, z, p, q) = 0,$$

of which (I′) is said to be the *general primitive.*

3. Similarly, if we are given any equation including three arbitrary constants a, β, γ, and three independent variables x, y, z,

$$f\,(x, y, z, w, a, \beta, \gamma) = 0, \tag{II}$$

we may differentiate this equation with respect to the independent variables x, y, z, thus obtaining

$$\left(\frac{df}{dx}\right) = 0, \left(\frac{df}{dy}\right) = 0, \left(\frac{df}{dz}\right) = 0\,;$$

and, by eliminating a, β, γ between the four equations stated, we would get a partial differential equation in three independent variables, in general non-linear,

$$\mathrm{F}\left(x, y, z, w, \frac{dw}{dx}, \frac{dw}{dy}, \frac{dw}{dz}\right) = 0,$$

of which (II) would be said to be a complete primitive.

If, instead of differentiating with respect to the independent variables, we had differentiated with respect to the arbitrary constants, thus getting

$$\frac{df}{da} = 0, \frac{df}{d\beta} = 0, \frac{df}{d\gamma} = 0,$$

and then eliminated the arbitrary constants between the given equation and these three, we would obtain a result of the form

$$\mathbf{F}\,(x, y, z, w) = 0,$$

which will, in general, satisfy the partial differential equation, previously derived,

$$\mathrm{F}\left(x, y, z, w, \frac{dw}{dx}, \frac{dw}{dy}, \frac{dw}{dz}\right) = 0,$$

and, as it exhibits no arbitrary constants, may be denominated its singular solution.

4. Again if, u and v being any functions of known form in x, y, z, w, we were given an equation of the type

$$f_{\prime\prime}\{x, y, z, w, \phi(u, v)\} = 0, \qquad \text{(II}'\text{)}$$

ϕ being any arbitrary function, we may differentiate with respect to the independent variables x, y, z, and eliminate

$$\phi, \frac{d\phi}{du}, \frac{d\phi}{dv},$$

thus again obtaining a partial differential equation

$$\mathrm{F}_{\prime\prime}\left(x, y, z, w, \frac{dw}{dx}, \frac{dw}{dy}, \frac{dw}{dz}\right) = 0,$$

of which (II′) may be said to be the general primitive.

5. Proceeding by analogy, being given any equation in two independent variables, but exhibiting *five* arbitrary constants,

$$f(x, y, z, \alpha, \beta, \gamma, \delta, \epsilon) = 0, \qquad \text{(III)}$$

we may differentiate this equation twice successively with respect to x and y, and eliminate the arbitrary constants between the given equation and

$$\left(\frac{df}{dx}\right) = 0, \left(\frac{df}{dy}\right) = 0, \left(\frac{d^2f}{dx^2}\right) = 0, \left(\frac{d^2f}{dxdy}\right) = 0, \left(\frac{d^2f}{dy^2}\right) = 0.$$

Thus we should obtain a partial differential equation of the second order, in general non-linear, of the form (adopting the ordinary notation),

$$\mathrm{F}(x, y, z, p, q, r, s, t) = 0, \qquad \text{(IV)}$$

of which (III) may be said to be a complete primitive.

6. It does not follow, however, (as is known), that, in general, from a given finite equation exhibiting *two arbitrary functions*, we can pass to a partial differential equation of the second order. For if, u and v being any two functions of known form in x, y, z, we were given any equation of the type

$$f(x, y, z, \phi u, \psi v) = 0,$$

differentiating this equation twice successively with respect to x and y

we only get six equations, which, ordinarily, are *not* sufficient to enable us to eliminate *the six* quantities

$$\phi,\ \phi',\ \phi'',\ \psi,\ \psi',\ \psi''.$$

It is true indeed that, in the case of *linear* partial differential equations of the second order, *which admit of treatment by symbolic methods,* we do, in most cases, obtain the solutions, in the form of general primitives, by direct procedures, and exhibiting two arbitrary functions. But the fact, which has just been alluded to, would appear to show that in the case of *non-linear* partial differential equations of the second and higher orders, which do not admit in general of treatment by symbolic methods, the species of solution which we should seek to obtain, should be, not the general primitive exhibiting arbitrary functions, but the complete primitive exhibiting arbitrary constants; and the mode of integration which we should seek to perfect, should be that by which the complete primitives of such partial differential equations are sought, and not their general primitives.

7. Moreover, we may differentiate the equation

$$f(x,\ y,\ z,\ a,\ \beta,\ \gamma,\ \delta,\ \epsilon) = 0$$

with respect to the arbitrary constants, and between the five equations thus found, namely,

$$\frac{df}{da} = 0,\ \frac{df}{d\beta} = 0,\ \frac{df}{d\gamma} = 0,\ \frac{df}{d\delta} = 0,\ \frac{df}{d\epsilon} = 0,$$

and the given equation, eliminate $a,\ \beta,\ \gamma,\ \delta,\ \epsilon$, thus obtaining a resulting equation of the form

$$\mathbf{F}_{\prime}\,(x,\ y,\ z) = 0. \tag{V}$$

It may be interesting to inquire what relation this equation bears to the corresponding partial differential equation (IV); in other words, whether there is any such relation between the two, as would justify us in denominating (V), *in any case,* the singular solution of (IV): what analytical conditions would be requisite in order that the former equation should satisfy the latter: and what may be the geometrical significance of singular solutions of partial differential equations of the second order, if such singular solutions are admissible or conceivable.

As regards the analytical conditions specified, they may be investigated thus. Differentiating the equation

$$f(x,\ y,\ z,\ a,\ \beta,\ \gamma,\ \delta,\ \epsilon) = 0$$

with respect to all the variables, we get identically

$$\left(\frac{df}{dx}\right)dx + \left(\frac{df}{dy}\right)dy + \frac{df}{da}\,da + \frac{df}{d\beta}\,d\beta + \frac{df}{d\gamma}\,d\gamma + \frac{df}{d\delta}\,d\delta + \frac{df}{d\varepsilon}\,d\varepsilon = 0,$$

which, in consequence of the relations supposed, reduces to

$$\left(\frac{df}{dx}\right) dx + \left(\frac{df}{dy}\right) dy = 0,$$

or, as dx and dy are independent, we have the first two of the relations stated in the fifth article, namely,

$$\left(\frac{df}{dx}\right) = 0, \left(\frac{df}{dy}\right) = 0.$$

So far all is plain; but when we proceed to differentiate these equations again with respect to all the variables, we get

$$\left(\frac{d^2f}{dx^2}\right) dx + \left(\frac{d^2f}{dxdy}\right) dy + \left(da\,\frac{d}{da} + d\beta\,\frac{d}{d\beta} + d\gamma\,\frac{d}{d\gamma} + d\delta\,\frac{d}{d\delta} + d\varepsilon\,\frac{d}{d\varepsilon}\right)\left(\frac{df}{dx}\right) = 0$$

$$\left(\frac{d^2f}{dy^2}\right) dy + \left(\frac{d^2f}{dxdy}\right) dx + \left(da\,\frac{d}{da} + d\beta\,\frac{d}{d\beta} + d\gamma\,\frac{d}{d\gamma} + d\delta\,\frac{d}{d\delta} + d\varepsilon\,\frac{d}{d\varepsilon}\right)\left(\frac{df}{dy}\right) = 0,$$

which are not equivalent to the remaining relations of the fifth article, namely,

$$\left(\frac{d^2f}{dx^2}\right) = 0, \left(\frac{d^2f}{dxdy}\right) = 0, \left(\frac{d^2f}{dy^2}\right) = 0,$$

unless, simultaneously,

$$\left.\begin{array}{l} \left(da\,\frac{d}{da} + d\beta\,\frac{d}{d\beta} + d\gamma\,\frac{d}{d\gamma} + d\delta\,\frac{d}{d\delta} + d\epsilon\,\frac{d}{d\epsilon}\right) . \left(\frac{df}{dx}\right) = 0 \\ \left(da\,\frac{d}{da} + d\beta\,\frac{d}{d\beta} + d\gamma\,\frac{d}{d\gamma} + d\delta\,\frac{d}{d\delta} + d\epsilon\,\frac{d}{d\epsilon}\right) . \left(\frac{df}{dy}\right) = 0 \end{array}\right\}$$

8. It is known that, if we are given any system of surfaces exponible by the partial differential equation of the first order

$$\mathrm{F}\,(x, y, z, p, q) = 0,$$

we can, in general, determine the character of this system by finding the integral of the differential equation, either in the form of a complete primitive, or a general primitive.

Again, if we are given any system of surfaces exponible by the partial differential equation of the second order

$$\mathrm{F}\,(x, y, z, p, q, r, s, t) = 0,$$

we may, in general, determine the character of this system by finding, if we can, the integral of the differential equation, either in the form of a complete primitive, or a general primitive.

If the solution, in either of these two cases, be obtained in the form of a general primitive, the form of the arbitrary function or functions introduced is, in general, determined by supposing the surface to pass through a given curve or curves. The difficulty of applying this principle, in practice, is well known.

If, on the other hand, the solution, in either case, be obtained in the form of a complete primitive, everything required by the solution is determined if, in the former case, *two points* upon the surface represented by the partial differential equation be given, and, in the latter case, *five points*. More generally, if the given non-linear partial differential equation be of the first order and include n independent variables, it is sufficient, for the determination of the function represented, in the form of a complete primitive, that we be given n systems of correspondent values of the variables. If the given non-linear partial differential equation be of the second order, and include n independent variables, it is sufficient for the complete determination of the function represented, that we be given $\frac{n(n+3)}{2}$ systems of correspondent values of the variables.

9. I now proceed to discuss certain examples with the view of showing the *feasibility* of obtaining solutions, in the form of complete primitives, of non-linear partial differential equations of the second order, and, in the following article, a general method for deriving such solutions will be indicated: the completion of the subject is reserved for a supplementary communication.

Examples.

(1). Let it be proposed to determine the solution, in the form of a complete primitive, of the non-linear partial differential equation

$$\frac{1}{p}+\frac{1}{q}=1. \qquad (1)$$

The auxiliary system, adopting the method of Lagrange and Charpit, gives

$$dp=0,$$

since

$$\frac{dq}{dx}=0, \frac{dq}{dz}=0.$$

Hence, c being any arbitrary constant,

$$p=c \quad , \quad \text{and} \quad q=\frac{c}{c-1};$$

and substituting these values in the general equation

$$dz=pdx+qdy$$

we get, writing $\frac{1}{a}$ for c,

$$z = \frac{x}{a} + \frac{y}{1-a} + \beta. \tag{2}$$

This then is *a* complete primitive of the given equation, and it is at once seen to satisfy it. But, moreover, if we examine the other equations of the auxiliary system in this case, namely,

$$(p-1)^2\,dx = dy = \left(\frac{p-1}{p}\right)^2 dz,$$

we see that no other complete primitive is deducible. In other words, equation (2) is *the* complete primitive of (1).

If β be made an arbitrary function of a, we get as the general primary of (1)

$$\left.\begin{aligned} z &= \frac{x}{a} + \frac{y}{1-a} + \phi(a) \\ 0 &= \frac{x}{a^2} - \frac{y}{(1-a)^2} - \phi'(a) \end{aligned}\right\}.$$

(2). If it be now proposed to integrate the higher differential equation in three independent variables (and a corresponding method will apply generally)

$$\frac{1}{\frac{dw}{dx}} + \frac{1}{\frac{dw}{dy}} + \frac{1}{\frac{dw}{dz}} = 1,$$

let us assume for w the linear form

$$w = \frac{x}{a} + \frac{y}{\beta} + \frac{z}{\gamma} + \kappa,$$

where a, β, γ, κ are arbitrary constants. Then, by substitution, we find that this will be the solution required, if the arbitrary constants be connected by the relation

$$a + \beta + \gamma = 1.$$

Hence the complete primitive of the given equation is, writing γ for κ,

$$w = \frac{x}{a} + \frac{y}{\beta} + \frac{z}{1-(a+\beta)} + \gamma,$$

and the general primary

$$\left.\begin{aligned} w &= \frac{x}{a} + \frac{y}{\beta} + \frac{z}{1-(a+\beta)} + \phi(a,\beta) \\ 0 &= \frac{d}{da}\left\{\frac{x}{a} + \frac{y}{\beta} + \frac{z}{1-(a+\beta)} + \phi(a,\beta)\right\} \\ 0 &= \frac{d}{d\beta}\left\{\frac{x}{a} + \frac{y}{\beta} + \frac{z}{1-(a+\beta)} + \phi(a,\beta)\right\} \end{aligned}\right\} .$$

I have ventured to denominate the system of equations just written, the 'general primary' solution of the given partial differential equation, instead of, as it is usually denominated, the 'general primitive.' It would seem to be right to distinguish between the two cases, where one arbitrary constant is made an arbitrary function of one or more others, and where an arbitrary function of the variables is introduced. It is true, indeed, that in some cases these duplicate solutions coincide, as, for instance, in the case of the general functional equation of surfaces of revolution, namely,

$$lx + my + nz = \phi\,(x^2 + y^2 + z^2)$$

which may be readily identified with the general primary, obtained from the complete primitive

$$(x - c\cos\lambda)^2 + (y - c\cos\mu)^2 + (z - c\cos\nu)^2 = \gamma^2,$$

by putting $c = \psi(r)$; but such identification does not appear to be generally possible.

It is easy to see how the following non-linear partial differential equations are but modifications of the simple examples treated, namely,

$$\left.\begin{aligned} \frac{1}{p} + \frac{1}{q} &= \frac{k}{z} \\ \frac{x}{p} + \frac{y}{q} &= kz \\ \frac{x^m}{p} + \frac{y^m}{q} &= kz^m \end{aligned}\right\} ;\ \text{or}\ \left\{\begin{aligned} \frac{1}{\frac{dw}{dx}} + \frac{1}{\frac{dw}{dy}} + \frac{1}{\frac{dw}{dz}} &= \frac{k}{w} \\ \frac{x}{\frac{dw}{ax}} + \frac{y}{\frac{dw}{dy}} + \frac{z}{\frac{dw}{dz}} &= kw, \\ \frac{x^m}{\frac{dw}{dx}} + \frac{y^m}{\frac{dw}{dy}} + \frac{z^m}{\frac{dw}{dz}} &= kw^m, \end{aligned}\right.$$

the solutions being, respectively,

$$\left.\begin{aligned} \log z &= \frac{1}{k}\left(\frac{x}{a} + \frac{y}{1-a} + \beta\right) \\ z^3 &= \frac{1}{k}\left(\frac{x^2}{a} + \frac{y^2}{1-a} + \beta\right) \\ z^{m+1} &= \frac{1}{k}\left(\frac{x^{m+1}}{a} + \frac{y^{m+1}}{1-a} + \beta\right) \end{aligned}\right\}$$

and

$$\left.\begin{aligned}\log w &= \frac{1}{k}\left(\frac{x}{a} + \frac{y}{\beta} + \frac{z}{1-(a+\beta)} + \gamma\right)\\ w^2 &= \frac{1}{k}\left(\frac{x^2}{a} + \frac{y^2}{\beta} + \frac{z^2}{1-(a+\beta)} + \gamma\right)\\ w^{m+1} &= \frac{1}{k}\left(\frac{x^{m+1}}{a} + \frac{y^{m+1}}{\beta} + \frac{z^{m+1}}{1-(a+\beta)} + \gamma\right)\end{aligned}\right\}.$$

(3). If it were proposed to integrate the non-linear partial differential equation of the second order, in two independent variables,

$$\frac{1}{r} + \frac{1}{t} = \frac{1}{\frac{d^2z}{dx^2}} + \frac{1}{\frac{d^2z}{dy^2}} = 1,$$

we would assume, by analogy, the solution to be

$$z = \frac{x^2}{2a} + \frac{y^2}{2(1-a)} + \frac{xy}{\beta} + \frac{x}{\gamma} + \frac{y}{\delta} + \epsilon;$$

and it is instantly evident that this is a complete primitive of the given equation, since it satisfies it, and exhibits five arbitrary constants.

Similarly, the solution, in the form of a complete primitive, of the non-linear partial differential equation of the second order, in three independent variables,

$$\frac{1}{\frac{d^2w}{dx^2}} + \frac{1}{\frac{d^2w}{dy^2}} + \frac{1}{\frac{d^2w}{dz^2}} = 1,$$

is

$$w = \frac{x^2}{2a} + \frac{y^2}{2\beta} + \frac{z^2}{2(1-\overline{a+\beta})} + \frac{yz}{\gamma} + \frac{zx}{\delta} + \frac{xy}{\epsilon} + \frac{x}{\zeta} + \frac{y}{\eta} + \frac{z}{\theta} + \kappa,$$

since, as before, it satisfies the given partial differential equation, and exhibits nine arbitrary constants.

It is readily seen that if the former of the two partial differential equations now treated, had been

$$\frac{1}{r} + \frac{1}{s} + \frac{1}{t} = \frac{1}{\frac{d^2z}{dx^2}} + \frac{1}{\frac{d^2z}{dxdy}} + \frac{1}{\frac{d^2z}{dy^2}} = 1,$$

we should have, for a complete primitive, the obvious modification

$$z = \frac{x^2}{2a} + \frac{y^2}{2\beta} + \frac{xy}{1-(a+\beta)} + \frac{x}{\gamma} + \frac{y}{\delta} + \epsilon.$$

(4). It follows readily from the forms of solution arrived at in the examples just discussed, that the complete primitive of any non-linear partial differential equation of the type

$$f(p, q) = 0,$$

is the linear expression

$$z = ax + by + c,$$

where a and b are connected by the equation

$$f(a, b) = 0.$$

Thus the complete primitive of the partial differential equation

$$\frac{1}{p^m} + \frac{1}{q^m} = k$$

is

$$z = \frac{x}{a^{\frac{1}{m}}} + \frac{y}{(1-a)^{\frac{1}{m}}} + \beta.$$

More generally, the complete primitive of the partial differential equation in three independent variables

$$\frac{1}{\left(\frac{dw}{dx}\right)^m} + \frac{1}{\left(\frac{dw}{dy}\right)^m} + \frac{1}{\left(\frac{dw}{dz}\right)^m} = 1$$

is

$$w = \frac{x}{a^{\frac{1}{m}}} + \frac{y}{\beta^{\frac{1}{m}}} + \frac{z}{(1-a+\beta)^{\frac{1}{m}}} + \gamma.$$

Similarly, the integral of the partial differential equation

$$\frac{1}{r^m} + \frac{1}{t^m} = \frac{1}{\left(\frac{d^2z}{dx^2}\right)^m} + \frac{1}{\left(\frac{d^2z}{dy^2}\right)^m} = 1,$$

in the form of a complete primitive, is

$$z = \frac{x^2}{2a^{\frac{1}{m}}} + \frac{y^2}{2(1-a)^{\frac{1}{m}}} + \frac{xy}{\beta} + \frac{x}{\gamma} + \frac{y}{\delta} + \epsilon;$$

and the solution of

$$\frac{1}{\left(\frac{d^2w}{dx^2}\right)^m} + \frac{1}{\left(\frac{d^2w}{dy^2}\right)^m} + \frac{1}{\left(\frac{d^2w}{dz^2}\right)^m} = 1$$

is

$$w = \frac{x^3}{2a^{\frac{1}{m}}} + \frac{y^3}{2\beta^{\frac{1}{m}}} + \frac{z^2}{2(1 - \overline{a + \beta})^{\frac{1}{m}}} + \frac{yz}{\gamma} + \frac{zx}{\delta} + \frac{xy}{\varepsilon} + \frac{x}{\zeta} + \frac{y}{\eta} + \frac{z}{\theta} + \kappa.$$

So, again, the complete primitive of the partial differential equation

$$\frac{1}{r^m} + \frac{1}{s^m} + \frac{1}{t^m} = 1,$$

is

$$z = \frac{x^2}{2a^{\frac{1}{m}}} + \frac{y^2}{2\beta^{\frac{1}{m}}} + \frac{xy}{(1 - \overline{a + \beta})^{\frac{1}{m}}} + \frac{x}{\gamma} + \frac{y}{\delta} + \epsilon.$$

(5.) It may be interesting to compare for a particular case the solution in the form of a complete primitive with the solution in the form of a general primitive. Thus let us take the equation

$$r + 2s + t = \frac{d^2z}{dx^2} + 2\frac{d^2z}{dxdy} + \frac{d^2z}{dy^2} = 1.$$

The solution of this equation by the symbolic method, in the form of a general primitive, is readily found to be

$$z = \frac{xy}{2} + \frac{x + y}{2} . \phi(x - y) + \psi(x - y).$$

The solution of the same equation, in the form of a complete primitive, is

$$z = \tfrac{1}{2}\{ax^2 + \beta y^2 + (1 - \overline{a + \beta})\, xy\} + \gamma x + \delta y + \epsilon.$$

These solutions may be readily identified by assuming

$$\phi(x - y) = A(x - y) + A',$$
$$\psi(x - y) = B(x - y)^2 + B'(x - y) + B'',$$

whence, by substitution in the former, we get

$$z = \frac{xy}{2} + \tfrac{1}{2}\{A(x^2 - y^2) + A'(x + y)\} + \{B(x - y)^2 + B'(x - y) + B''\}$$

and, by comparison of co-efficients,

$$\tfrac{1}{2}A + B = \tfrac{1}{2}\alpha,\ B - \tfrac{1}{2}A = \tfrac{1}{2}\beta,\ 2B = \tfrac{1}{2}(\alpha + \beta),$$
$$\tfrac{1}{2}A' + B' = \gamma,\ \tfrac{1}{2}A' - B' = \delta, \quad B'' = \epsilon.$$

A similar identification may be performed upon the solutions, in the two forms, of the equation

$$r + t = 1.$$

Thus it appears that the general primitive may be reduced to the complete primitive, but not *vice versâ*.

(6.) The following will serve as examples of the latter portion of the third article. Let the partial differential equation proposed for solution be

$$x\frac{dw}{dx}+y\frac{dw}{dy}+z\frac{dw}{dz}=\left\{a^m\left(\frac{dw}{dx}\right)^m+b^m\left(\frac{dw}{dy}\right)^m+c^m\left(\frac{dw}{dz}\right)^m\right\}^{\frac{1}{m}},$$

where a, b, c are given constants: then the solution of this equation, in the form of a complete primitive, is

$$w=\alpha x+\beta y+\gamma z-\{a^m\alpha^m+b^m\beta^m+c^m\gamma^m\}^{\frac{1}{m}}=0,$$

and the singular solution is

$$\left(\frac{x}{a}\right)^{\frac{m}{m-1}}+\left(\frac{y}{b}\right)^{\frac{m}{m-1}}+\left(\frac{z}{c}\right)^{\frac{m}{m-1}}=1.$$

Thus, if $m=3$, the singular solution of the partial differential equation

$$x\frac{dw}{dx}+y\frac{dw}{dy}+z\frac{dw}{dz}=\left\{a^3\left(\frac{dw}{dx}\right)^3+b^3\left(\frac{dw}{dy}\right)^3+c^3\left(\frac{dw}{dz}\right)^3\right\}^{\frac{1}{3}}$$

is

$$\left(\frac{x}{a}\right)^{\frac{3}{2}}+\left(\frac{y}{b}\right)^{\frac{3}{2}}+\left(\frac{z}{c}\right)^{\frac{3}{2}}=1.$$

Again, if $m=\frac{1}{2}$, the singular solution of

$$x\frac{dw}{dx}+y\frac{dw}{dy}+z\frac{dw}{dz}=\left\{\left(a\frac{dw}{dx}\right)^{\frac{1}{2}}+\left(b\frac{dw}{dy}\right)^{\frac{1}{2}}+\left(c\frac{dw}{dz}\right)^{\frac{1}{2}}\right\}^2$$

is

$$\frac{a}{x}+\frac{b}{y}+\frac{c}{z}=1.$$

Finally, it is easily proved that the singular solution of the partial differential equation

$$a\frac{dw}{dx}\left\{x\frac{dw}{dx}+y\frac{dw}{dy}+z\frac{dw}{dz}\right\}+b^2\left(\frac{dw}{dy}\right)^2+c^2\left(\frac{dw}{dz}\right)^2=0$$

is the paraboloid

$$\frac{y^2}{b^3}+\frac{z^2}{c^2}=\frac{4x}{a}.$$

Generalisation of Charpit's Method.

10. Let us suppose that the given non-linear partial differential equation is reduced to the form

$$s = f(x,\ y,\ z,\ p,\ q,\ r,\ t).$$

Then we have the two conditions

$$\left(\frac{dr}{dy}\right) = \left(\frac{ds}{dx}\right),\quad \left(\frac{dt}{dx}\right) = \left(\frac{ds}{dy}\right).$$

Now on supposition that r is expressed generally as a function of x, y, z, p, and q, we have

$$\left(\frac{dr}{dy}\right) = \frac{dr}{dy} + \frac{dr}{dz}\,q + \frac{dr}{dp}\,s + \frac{dr}{dq}\,t,$$

and

$$\left(\frac{ds}{dx}\right) = \frac{ds}{dx} + \frac{ds}{dz}p + \frac{ds}{dp}r + \frac{ds}{dq}s + \frac{ds}{dr}\left(\frac{dr}{dx} + \frac{dr}{dz}p + \frac{dr}{dp}r + \frac{dr}{dq}s\right)$$
$$+ \frac{ds}{dt}\left(\frac{dt}{dx} + \frac{dt}{dz}p + \frac{dt}{dp}r + \frac{dt}{dq}s\right).$$

Hence, equating and arranging terms, we get a linear partial differential equation in r and t as dependent variables, and x, y, z, p, q as independent variables, namely,

$$\left.\begin{aligned} &-\frac{ds}{dr}\cdot\frac{dr}{dx} + \frac{dr}{dy} + \left(q - p\,\frac{ds}{dr}\right)\frac{dr}{dz} + \left(s - r\,\frac{ds}{dr}\right)\frac{dr}{dp} + \left(t - s\,\frac{ds}{dr}\right)\frac{dr}{dq} \\ &-\frac{ds}{dt}\left(\frac{dt}{dx} + p\,\frac{dt}{dz} + r\,\frac{dt}{dp} + s\,\frac{dt}{dq}\right) = \frac{ds}{dx} + \frac{ds}{dz}p + \frac{ds}{dp}r + \frac{ds}{dq}s \end{aligned}\right\}(a)$$

in which, of course, the co-efficients $\frac{ds}{dx}, \frac{ds}{dy}, \frac{ds}{dz}, \frac{ds}{dp}$, &c., are all known functions of x, y, z, p, q, r, and t.

The second condition gives the corresponding equation

$$\left.\begin{aligned} &\frac{dt}{dx} - \frac{ds}{dt}\cdot\frac{dt}{dy} + \left(p - q\,\frac{ds}{dt}\right)\frac{dt}{dz} + \left(r - s\,\frac{ds}{dt}\right)\frac{dt}{dp} + \left(s - t\,\frac{ds}{dt}\right)\frac{dt}{dq} \\ &-\frac{ds}{dr}\left(\frac{dr}{dy} + q\,\frac{dr}{dz} + s\,\frac{dr}{dp} + t\,\frac{dr}{dq}\right) = \frac{ds}{dy} + \frac{ds}{dz}q + \frac{ds}{dp}s + \frac{ds}{dq}t \end{aligned}\right\}(\beta)$$

in which, as before, the co-efficients $\frac{ds}{dy}, \frac{ds}{dz}$, &c., are known functions of x, y, z, p, q, r, and t.

This system of simultaneous partial differential equations may be much simplified by writing

$$\frac{d}{dx} + p\frac{d}{dz} + r\frac{d}{dp} + s\frac{d}{dq} = X,$$

$$\frac{d}{dy} + q\frac{d}{dz} + s\frac{d}{dp} + t\frac{d}{dq} = Y,$$

$$\frac{ds}{dx} + p\frac{ds}{dz} + r\frac{ds}{dp} + s\frac{ds}{dq} = f_1(x, y, z, p, q, r, t)$$

$$\frac{ds}{dy} + q\frac{ds}{dz} + s\frac{ds}{dp} + t\frac{ds}{dq} = f_2(x, y, z, p, q, r, t)$$

$$\frac{ds}{dr} = R, \frac{ds}{dt} = T.$$

By making these substitutions, the given system of simultaneous partial differential equations becomes, simply,

$$\left.\begin{array}{l} Y.r - RX.r - TX.t = f_1 \\ X.t - TY.t - RY.r = f_2 \end{array}\right\}$$

Hence, in general, we have a system of two simultaneous linear partial differential equations to determine r and t in terms of p, q, x, y, z. Supposing these found, it remains to substitute their values in

$$\left.\begin{array}{l} dp = rdx + sdy \\ dq = sdx + tdy \end{array}\right\}$$

and integrate again. The values of p and q thus found are to be substituted, finally, in the equation

$$dz = pdx + qdy,$$

and by a third integration the solution required is, in general, determined. It will be evident that in the processes of successive integration indicated, five arbitrary constants are introduced.

XVII.—On the Comparative Value of the different Feeding Substances for Horses. By John Dowling, Student in the Evening Practical Chemical Class, Museum of Irish Industry.

[Read before the Royal Dublin Society, Monday, June 18, 1860.]

These experiments and accompanying analyses were undertaken with a double object in view:—1st, To ascertain the feeding values of different descriptions of horse foods; 2nd, To ascertain their chemical values, and, in connexion with their feeding values, to determine the conditions under which each and every sort of food is best adapted for use in producing work or making flesh. I regret that I have been unable to carry these experiments and analyses as far as I could have wished.

The analyses were conducted in the usual way. The moisture was determined by drying a weighed quantity of the substance at 212°, until it ceased to lose weight. For Indian-corn, bran, toppings, oats, and rape, I took 50 grs. of each; the oil, for which I took 50 grs., was dissolved out by ether, the ether subsequently distilled off, and the residual oil dried at 212°, till it ceased to lose weight; the ash, for which I took 50 grs. of substance, was estimated by igniting a weighed quantity until all organic matter was consumed; the albumen was determined by the quantity of nitrogen obtained by combustion of a weighed quantity of substance with soda-lime. In calculating, I have taken 15·92 as the quantity of nitrogen in 100 parts of vegetable albumen. The fibre was estimated by digesting 50 grs. for some days with dilute solution of potash, washing with acidified water, and finally with pure water, drying the residue at 212°, until it ceased to lose weight. The starch was estimated by difference.

When the oil is calculated as starch, I have from calculation found 10 of oil to equal 24 of starch. I have also determined, in the different samples of hay, the quantity of matter soluble in water; and have estimated in each case the ash and nitrogen, and in hay, L, the quantity of matter soluble in ether. To show what constituents are removed from the hay by the water, and their quantities, I have contrasted the composition of the hay, dried at 212° F., but not digested, with the composition of the digested hay, dried at 212° F. Two estimations were made of the substances in the digested portion, but I have only given the mean of the two. The different samples of hay I digested in water had previously been dried at 212° F. The substances which are removed from the hay by water, as the analyses show, are some of the mineral constituents—sugar and the colouring matter: the albuminous compounds were insoluble in water. When hay or grass is digested in ether, the ethereal solution has a beautiful green colour; but the colour of the ethereal solution from the digested hay is not green; indeed, it has very little, if any colour: the colouring matter is, therefore, destroyed, or altered in character by the water. This part of the investigation explains the nature of the changes which hay suffers on exposure to rain.

The scientific part of the investigation was conducted in the laboratory of the Museum of Irish Industry, under the direction of Mr. Galloway.

From May 24 to July 4, the work-horses were fed on a mixture of crushed Indian corn, Irish oats, and bran from Black Sea wheat. The Indian corn cost 30*s.* per 480 lbs., the oats, 15*s.* 6*d*, per 196 lbs., and the bran, 4*s.* 6*d.* per 112 lbs. The analyses of these articles are given in a succeeding page; they are marked 1, 2, and 3. They also consumed in the above time 16 cwts. of first-crop hay, clover, and grasses, growth of 1858, costing 4*s.* 3*d.* per 112 lbs. The analysis of this hay is distinguished by the letter D.

The following tabular form gives the dates on which each weighing of food was given, the number of horses it kept, and the results as to quantity consumed and work performed :—

Dates.		No. of Horses and Time.	Grain Mixture.			Average per day consumed.	Days lasted.			Work performed.		
From	To		Indian Corn.	Oats.	Bran.		Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
May 24,	June 9,	3, whole time,	480	128	112	14·17	17	7	10	188½	9·0	3·27
June 10,	June 26,	ditto,	480	128	112	14·17	17	8	9	129	5·3	2·53
June 27,	July 4,	2 for 8 days, 1 for 2 days,	180	45	45	15·00	8	5	3	73½	6·1	4·08
Totals and Averages		2 for 42 days, 1 for 36 days,	1140	301	269	14·25	42	20	22	391	6·86	3·26

16 cwts. of hay for the above time and number of horses, that is, 2 horses for 42 days, and 1 horse for 36 days, is = 14·94 lbs. per day per horse.

	lbs.		*d.*
Average, per day per horse, grain mixture,	14·25,	costing	10·6
Do., do. hay,	14·94	,,	6·8
Total food and cost, per day, per horse, .	29·19	,,	17·4

The horses consumed per day each 1·19 lbs. of oil = 2·85 lbs. starch, 12·64 lbs. starch, and 1.59 lbs. albumen. The starch, and oil calculated as starch = 15·49 lbs., and contained 6·88 lbs. of carbon. The ratio between the nitrogenous and non-nitrogenous is as 1 to 9·7.

The above food caused, for about three weeks, a slight scouring; it has now disappeared, and there remains but a slight looseness. The excrements have an intolerable odour. The horses have not lost flesh; they continue in good condition, but there is no apparent gain of flesh.

From July 5 to August 17, the horses were fed on the mixture of Indian corn, oats, and bran, the same as was used from May 24 to July 4, and at the same prices; and 14 cwts. of hay, at 5*s.* 3*d.* per 112 lbs., first crop clover and mixed grasses, growth of 1858. The analysis of this hay is distinguished by the letter E.

The following Table gives the dates of each weighing of food, the number of horses it kept, and the results as to quantity consumed, and work performed:—

Dates.		No. of Horses and Time.	Grain Mixture.			Average per day consumed.	Days.			Work performed.		
From	To		Indian Corn.	Oats.	Bran.		Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
July 5,	July 12,	2 for 8 days, 1 for 4 days,	240	60	60	18·00	8	6	2	72½	4·53	3·62
July 13,	July 20,	2, whole time,	240	60	60	22·50	8	8	.	86¾	5·42	5·42
July 21,	July 30,	ditto,	240	60	60	18·00	10	5	5	33½	3·35	1·68
July 31,	Aug. 17,	ditto,	480	120	120	20·00	18	18	.	265¾	7·38	7·38
Totals and Averages,		2 for 44 days, 1 for 4 days,	1200	300	300	19·56	44	37	7	458½	5·88	4·98

The 14 cwts, of hay for the above time = 17 lbs. per day per horse. 2 horses for 44 days, and 1 horse for 4 days.

	lbs.		*d.*
Average, per day per horse, grain mixture,	19·56,	costing	14·45
Do., do. hay,	17·00	,,	9·56
Total food and cost, per day, per horse,	36·56	,,	24·01

The horses consumed in the above food per day each 1·54 lbs. of oil = 3·70 lbs. of starch, 15·24 lbs. of starch, and 2·37 lbs. of albumen. The starch, and oil calculated as starch = 18·94 lbs., and contained 8·41 lbs. of carbon. The ratio between the nitrogenous and non-nitrogenous is as 1 to 8.

The horses have improved very much this period; they are putting up flesh rapidly, although the work has been much increased. Their excrements have nearly lost the intolerable odour which I mentioned in the first period.

From August 18 to September 15, 1859, the horses were fed on a mixture of Indian corn and oats, the same sorts as used in the previous periods, and at the same prices.

The hay used from August 18 to August 27, was 336 lbs. of load E, which was consumed at the rate of 17 lbs. per day per horse; cost 5*s*. 3*d*. per 112 lbs. The hay used from August 28 to September 15, was 849 lbs. of load F, cost 5*s*. per 112 lbs., which was consumed at the rate of 22·34 lbs. per day, per horse.

The following Table gives the dates of each weighing of food, the number of horses it kept, and the result as to work, &c.:—

Dates.		No. of Horses and Time.	Grain Mixture.		Consumed per day.		Days.			Work performed.		
From	To		Indian Corn.	Oats.	Grain.	Hay.	Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
Aug. 18,	Aug. 27,	2 whole time,	240	120	18·0	17·0	10	8	2	130	8·12	6·50
„ 28,	Sept. 5,	2 „	240	120	20·0	22·34	9	6	3	125	10·41	6·94
Sept. 6,	Sept. 15.	2 „	240	120	18·0	22·34	10	6	4	114	9·50	5·70
Totals and Averages,		2 for 29 days,	720	360	18·62	20·43	29	20	9	369	9·22	6·36

	lbs.		*d.*
Average per day, per horse, of grain mixture,	18·62,	cost	15·20
Do., do. hay, . . .	20·43	,,	11·10
Total food and cost, per day, per horse,	39·05		26·30

The horses consumed each, per day, in the above food, 1·72 lbs of oil = 4·13 lbs. starch, 16·57 lbs. starch, and 2·52 lbs. albumen.

The starch, and oil calculated as starch, = 20·70 lbs., and contain 9·20 of carbon. The ratio between the nitrogenous and non-nitrogenous constitutents is as 1 to 8·21.

The above feeding kept the horses in fine condition. It had a tendency to induce costiveness. The horses leave the very fine Indian corn meal, and eat only the oats and coarse portion of the Indian corn. The hay used from August 28 to September 15, was short and brittle—consequently wasteful.

From September 16 to November 3, 1859, the horses were fed on a mixture of Odessa Indian corn, Irish bran, and toppings; the Indian corn cost 31*s*. per 480 lbs.; the bran, 5*s*. per 112 lbs.; and the toppings, 4*s*. 6*d*. per 112 lbs. The analyses of these are marked 4, 5, and 6.

From September 16 to October 11, there were used 1251 lbs. hay, load F, cost 5*s.*, averaging 22·34 lbs. per day per horse; from October 12 to November 3, there were used 1288 lbs. of load J of hay, at 4*s.* 11*d.* per 112 lbs.; averaging 18·66 lbs. per day per horse.

The following Table gives the dates of each weighing of food, the number of horses it kept, and the result as to consumption, work, &c.:—

Dates.		No. of Horses and Time.	Grain Mixture.			Average per Day consumed.	Days.			Work performed.		
From	To		Indian Corn.	Bran.	Toppings.		Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
Sept. 16,	Sept. 26,	2 for 11 days,	240	60	60	16·36	11	6	5	54	4·50	2·45
Sept. 27,	Oct. 6,	2 for 10 days,	240	50	50	17·00	10	4	6	25	3·12	1·25
Oct. 7,	Oct. 13,	2 for 7 days, 1 for 6 days,	240	60	60	18·00	7	5	2	90	6·00	4·50
Oct. 14,	Oct. 24,	3 for 11 days,	480	112	112	21·33	11	11	.	384	11·63	11·63
Oct. 25,	Nov. 3,	3 for 10 days,	480	112	112	23 46	10	10	.	147	4·90	4·90
Totals and Averages,		2 for 22 days, 3 for 27 days,	1680	394	394	19·74	49	36	13	700	7·14	5·60

2539 lbs. of hay, as above, consumed by 2 horses, feeding for 22 days, and 3 horses, feeding for 27 days, averaged 20·24 lbs. per day per horse.

	lbs.		*d.*
Average per day, per horse, of grain mixture,	19·74,	cost	13·62
Do. do. hay, . . .	20.24,	,,	10·80
Total food, and cost per day, per horse,	39·98,		24·42

The horses consumed per day, each, in the above food, 2 lbs. of oil = 4·8 lbs. starch, 16·90 lbs. of starch, and 2·82 lbs. of albumen.

The starch, and oil calculated as starch = 21·70 lbs., and contain 9·64 lbs. of carbon. The ratio between nitrogenous and non-nitrogenous is as 1 to 7·7.

The horses have kept in fine condition during this period, excepting the first 11 days, when they looked cold and hairy.

From the 4th to the 15th November, 1859, the horses were fed on a mixture composed of Odessa yellow Indian corn and toppings, same sorts as were used in the last experiment, and at the same prices.

The balance, 672 lbs. of the load J of hay, was also eaten this period; it averaged 18·66 lbs. per day, per horse.

The following Table gives the particulars as to consumption, work, number of horses, &c. :—

Dates.		No. of Horses and Time.	Grain Mix.		Consumption per Day, Grain Mixture.	Consumption per Day of Hay.	Days.			Work performed.		
From	To		Indian Corn.	Toppings.			Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
Nov. 4,	Nov. 15,	3 for 12 days,	480	280	21·11	18·66	12	10	2	185	6·17	5·13
Totals and Averages		3 for 12 days,	480	280	21·11	18·66	12	10	2	185	6·17	5·13

	lbs.		d.
Average per horse, per day, of grain mixture,	21·11,	cost	14·08
Do. do. hay, . . .	18·66,	,,	9·83
Total food, and cost per day, per horse,	39·77,		23·91

The horses consumed each, per day, in the above feeding, 1·90 lbs. of oil = 4·56 lbs. starch, 17·16 lbs. starch, and 2·35 lbs. of albumen.

The starch, and oil calculated as starch = 21·72 lbs, which contain 9·65 lbs. of carbon. The ratio between the nitrogenous and non-nitrogenous constituents is as 1 to 9·24.

No change to notice in the horses during this period.

From November 18 to December 1, 1859, the horses were fed on a mixture of Galatz Indian corn and Irish bran. The Indian corn cost 34*s.* per quarter = £7 18*s.* 8*d.* per ton ; the bran cost 6*s.* per 112 lbs. 744 lbs. of load K of hay, at 6*s.* 2*d.* per 112 lbs. The analysis of Galatz corn is marked 7.

The following Table furnishes particulars as to number of horses, quantity of food, and work performed:—

Dates.		No. of Horses and Time.	Grain Mix.		Consumption per Day, Grain Mixture.	Consumption per Day of Hay.	Days.			Work performed.		
From	To		Indian Corn.	Bran.			Total.	Worked.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.						Tons.	Tons.	Tons.
Nov. 18,	Dec. 1,	3 for 14 days,	462	336	19·00	17·70	14	11	3	229	6·94	5·45
Totals and Averages,		3 for 14 days,	462	336	19·00	17·70	14	11	3	229	6·94	5·45

	lbs.		d.
Average per day, per horse, grain mixture,	19·00,	cost	14·47
Do. do. hay, . . .	17·70,	,,	11·69
Total food, and cost per day, per horse,	36·70		26·16

The horses consumed each, per day, in the above feeding, 1·25 lbs. of oil = 3 lbs of starch, 16·05 lbs. starch, and 3 lbs of albumen.

The starch, and oil calculated as starch = 19·05 lbs., and contain 8·46 lbs. carbon. The ratio between the nitrogenous and non-nitrogenous is as 1 to 6·35.

The horses work, and look well, on this feeding; it passes rather quickly through their stomachs; some of it, undigested, being noticeable in their excrements.

From December 2 to December 14, 1859, the horses were fed on a mixture composed of Galatz Indian-corn, bran from Irish wheat, and toppings. The Indian corn cost 34*s.* per qr. of 480 lbs.; the bran 6*s.* per 112 lbs.; and the toppings 4*s.* per 112 lbs.; and 690 lbs. hay, load K, at 6*s.* 2*d.* per 112 lbs. The analysis is marked 9.

The following Table furnishes particulars as to the number of horses kept, quantity of food used, and work performed:—

Date.		No. of Horses and Time.	Grain Mixture.			Grain Mixture per Day.	Hay per Day.	Days.			Work performed.		
From	To		Indian Corn.	Bran.	Toppings.			Total.	Work.	Idle.	Total.	Per Worked Day.	Per Day for Whole Time.
			lbs.	lbs.	lbs.	lbs.	lbs.				Tons,	Tons.	Tons.
Dec. 2,	Dec. 14,	3 for 13	462	224	112	20·46	17·70	13	10	3	247	8·23	6·33
Totals and Averages,		3 for 13	462	224	112	20·46	17·70	13	10	3	247	8·23	6·33

	lbs.		*d.*
Average per day, per horse, grain mixture, .	20·46,	cost	15·15
Do., do., hay, ...	17·70	,,	11·69
Total food and cost per horse, per day,	38·16		26·84

The horses consumed each, per day, in the above feeding, 1·21 lbs. of oil = 2·91 starch, 16·53 lbs of starch, and 2·88 lbs. of albumen. The starch, and oil calculated as starch, = 19·44 lbs., and contain 8·64 lbs. of carbon. The ratio between the nitrogenous and non-nitrogenous constituents is as 1 to 6·75.

The horses continue in prime order.

From December 15, 1859, to February 1, 1860, the horses were fed on a mixture composed of Galatz Indian corn, Irish bran, toppings, and rape-cake meal. The Indian corn, bran, and toppings, at the prices stated for last period. The rape-cake meal at 7*s.* per 112 lbs. The analysis of rape-cake is marked 9.

3696 lbs. of hay, load L, were used during the above period; it cost 6*s.* per 112 lbs.; 2nd crop clover and grasses, growth of 1859; its consumption averaged 25·11 lbs. per day, per horse.

The following table furnishes particulars as to the dates of each weighing of food, the number of horses kept, work performed, &c. :—

Dates.		No. of Horses and Time.	Grain Mixture.				Average per Day Grain Mixture.	Days.			Work performed.		
From	To		Indian Corn.	Bran.	Toppings.	Rape Cake		Total.	Worked.	Idle.	Total	Per Worked Day.	Per Day for Whole
			lbs.	lbs	lbs.	lbs.	lbs.				Tons.	Tons.	Tons.
Dec. 15,	Dec. 28,	3 for 14	252	112	112	56	12·66	14	9	5	83	3·07	2·00
„ 29,	1860. Feb. 1,	3 for 35	294	560	224	112	11·32	35	30	5	516	5·73	4·91
Totals and Averages,		3 for 49	546	672	336	168	11·71	49	39	10	599	5·12	4·07

	lbs.		*d.*
Average per day, per horse, grain mixture,	11·71,	cost	8·06
Do. do. hay, . . .	25·11,	,,	16·14
Total food, and cost per day, per horse,	36·82,		24·20

The horses consumed each, per day, 1·14 lbs. oil = 2·74 lbs. of starch, 11·12 lbs. starch, and 2·67 lbs. of albumen.

The starch, and oil calculated as starch = 13·86 lbs., and contain 6·16 lbs. of carbon. The ratio between the nitrogenous and non-nitrogenous constituents is as 1 to 5·20.

During the above time the weather was very severe, and roads bad. I believe that under the circumstances five tons per day is much harder work than 6 tons 5 cwt. in fine weather, when the roads are good and the days long.

5 tons = 4 loads. 6 tons 5 cwt. = 5 loads.

The horses got thin this period; they lost the flesh they put up in July, August, and September.

COMPARISON.

Dates.	Oil 10 = 24 Starch.	Starch as such.	Total Oil and Starch calculated as Starch.	Carbon in Food	Albumen.	Ratio of Plastic to Non-Nitrogen.	Tons per Day Worked.	Tons per Day, all Time.
May 24 to July 4, . .	1·19 = 2·85	12·64	15·49	6·88	1·59	1 : 9·70	6·86	3·26
July 5 to Aug. 17, . .	1·54 = 3·70	15·24	18·94	8·41	2·37	1 ; 8·00	5·88	4·98
Aug. 18 to Sept. 15, .	1·72 = 4·13	16·75	20·70	9·20	2·52	1 : 8·21	9·22	6·36
Sept. 16 to Nov. 3, .	2·00 = 4·80	16·90	21·70	9·64	2·82	1 : 7·70	7·14	5·60
Nov. 4 to Nov. 15, .	1·90 = 4·56	17·16	21·72	9·65	2·35	1 : 9·24	6·17	5·13
Nov. 18 to Dec. 1, . .	1·25 = 3·00	16·05	19·05	8·46	3·00	1 : 6·35	6·94	5·45
Dec. 2 to Dec. 14, . .	1·21 = 2·91	16·53	19·44	8·64	2·88	1 : 6·75	8·23	6·33
Dec. 15 to Feb. 1, . .	1·14 = 2·74	11·12	13·86	6·16	2·67	1 : 5·20	5·12	4·07

1. Irish black oats (growth of 1858), weighing 39 lbs. per bushel; price 15*s.* 6*d.* per 196 lbs.; used in the feeding experiments from May 24 to September 15, 1859.

	Analyses. I.	Analyses. II.	Mean.
Water,	11·41	11·83	11·62
Albuminous compounds (flesh-forming matters),	7·60	7·91	7·75
Oil, starch, sugar, &c., { fat and heat producing materials, }	5·92 42·67	5·86 42·04	5·89 42·36
Fibre (indigestible),	29·84	29·40	29·62
Ash (inorganic matter),	2·56	2·96	2·76
	100·00	100·00	100·00
Nitrogen,	1·21	1·26	1·235

Hay D, 1st crop clover and mixed grasses (growth 1858), 16 cwt., at 4*s.* 3*d.* per 112 lbs. Used in the feeding experiments from May 24 to July 4.

	Analyses. I.	Analyses. II.	Mean.
Water,	11·66	11·08	11·37
Albuminous compounds (flesh-forming matters),	3·66	4·57	4·12
Oil, Starch, { fat and heat producing materials. }	3·44 27·76	3·62 27·61	3·53 27·68
Fibre (indigestible),	45·98	46·06	46·02
Ash (inorganic matter)	7·50	7·06	7·28
	100·00	100·00	100·00
Nitrogen,	0·582	0·727	0·65

100 grains of the hay D, which had been dried at 212° F., weighed 75·75 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F.; 24·25 per cent. of this hay was therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay, dried at 212° F.
Albuminous compounds,	4·65	5·32
Ash,	8·21	3·93
Fibre,	51·92	51·92
Oil,	3·98	14·58
Starch, sugar, &c.,	31·23	
	99·99	75·75
Amount of matter in the hay soluble in water,		24·25
		100·00

2. Flat yellow American Indian corn, weighing 56½ lbs. per bushel; price 30*s.* per 480 lbs. = £7 per ton. Used in the feeding experiments from May 24 to September 15, 1859.

	Analyses.		
	I.	II.	Mean.
Water,	13·60	13·60	13·60
Albuminous compounds (flesh-forming matters),	5·82	6·30	6·06
Oil, {fat and heat producing	4·38	4·38	4·38
Starch, materials,}	70·08	69·54	69·81
Fibre (indigestible),	4·82	4·68	4·75
Ash (inorganic matter),	1·30	1·50	1·40
	100·00	100·00	100·00
Nitrogen,	0·926	1·003	0·964

3. Bran from Black Sea wheat, weighing 18·9 lbs. per bushel, price 4*d.* 6*d.* per 112 lbs. Used in the feeding experiments from May 24 to August 17, 1859.

	Analyses.		
	I.	II.	Mean.
Water,	12·16	11·97	12·07
Albuminous compounds (flesh-forming matters),	8·80	9·37	9·08
Oil, {fat and heat producing	4·04	4·38	4·21
Starch, materials.}	37·04	35·94	36·49
Fibre (indigestible),	30·26	30·86	30·56
Ash (inorganic matter),	7·70	7·48	7·59
	100·00	100·00	100·00
Nitrogen,	1·40	1·49	1.445

Hay E, 1st crop (growth of 1858), clover and mixed grasses; 17 cwt., price 5*s* 3*d.* per 112 lbs. Used in the feeding experiments from July 5 to August 27.

	Analyses.		
	I.	II.	Mean.
Water,	9·89	9·70	9·79
Albuminous compounds (flesh-forming matters),	5·98	6·15	6·07
Oil, {fat and heat producing	3·60	3·98	3·79
Starch, materials,}	21·41	21·11	21·26
Fibre, (indigestible),	51·08	51·10	51·09
Ash (inorganic matter),	8·04	7·96	8·00
	100·00	100·00	100·00
Nitrogen,	0·952	0·98	0·961

100 grains of the hay E, which had been dried at 212° F., weighed 77·19 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F.; 22·81 per cent. of this hay was therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay dried at 212° F.
Albuminous compounds, . .	6·73	6·78
Ash, ...	8·86	4·29
Fibre, ...	56·63	56·63
Oil, ...	4·20	9·49
Starch, sugar, &c., ...	23·57	
	99·99	77·19
Amount of matter in this hay soluble in water, . .		22·81
		100·00

Hay F, 2nd crop (growth 1859), clover and mixed grasses, $18\frac{3}{4}$ cwt., at 5*s*. per 112 lbs. Used in feeding from August 28 to October 11, 1859.

	Analyses.		
	I.	II.	Mean.
Water, ...	12·35	12·40	12·38
Albuminous compounds (flesh-forming matters), ...	6·15	6·59	6·37
Oil, fat and heat producing materials,	4·12	4·00	4·06
Starch,	27·68	27·61	27·64
Fibre (indigestible), ...	43·34	42·82	43·08
Ash (inorganic matter), ...	6·36	6·58	6·47
	100·00	100·00	100·00
Nitrogen, . . .	0·98	1·05	1·01

100 grains of the hay F, which had been dried at 212° F., weighed 74·74 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F.; 25·26 per cent. of this hay was therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay, dried at 212° F.
Albuminous compounds, . .	7·27	6·57
Ash, ...	7·28	3·52
Fibre, ...	49·16	49·16
Oil, ...	4·63	15·49
Starch, sugar, &c., ...	31·65	
	99·99	74·74
Amount of matter in the hay soluble in water, .		25·26

4. Odessa round yellow Indian corn, weighing $61\frac{1}{8}$ lbs. per bushel; price, 31*s*. per 480 lbs. = £7 4*s*. 8*d*. per ton. Used in feeding from Sept. 16 to November 15, 1859.

	Analyses.		
	I.	II.	Mean.
Water,	12·23	11·74	11·98
Albuminous compounds (flesh-forming matters),	9·37	8·80	9·09
Oil, } fat and heat producing	6·78	6·38	6·58
Starch, } materials,	65·30	66·02	65·66
Fibre (indigestible),	5·08	5·78	5·43
Ash (inorganic matter),	1·24	1·28	1·26
	100·00	100·00	100·00
Nitrogen,	1·49	1·40	1·445

Hay J, first crop, clover and grasses; growth 1859; $17\frac{1}{2}$ cwts., at 4*s*. 11*d*. per cwt. Used in feeding experiments from October 12 to November 14.

	Analyses.		Mean.
	I.	II.	
Water,	15·93	15·40	15·66
Albuminous compounds (flesh-forming materials)	4·40	5·27	4·83
Oil, } fat and heat producing	3·94	3·78	3·86
Starch, } materials,	27·53	28·67	28·11
Fibre (indigestible),	42·44	41·46	41·95
Ash (inorganic),	5·76	5·42	5·59
	100·00	100·00	100·00
Nitrogen,	0·70	0·84	0·77

100 grains of the hay J, which had been dried at 212° F, weighed 85·26 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F; 14·74 per cent. of this hay was therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay, dried at 212° F.
Albuminous compounds,	5·74	5·80
Ash,	6·63	3·72
Fibre,	49·62	49·62
Oil,	4·57	26·12
Starch, sugar, &c.,	33·43	
	99·99	85·62
Amount of matter in the hay soluble in water,		14·74
		100·00

5. Irish wheat bran, weighing 18 lbs. per bushel; price 5*s.* per 112 lbs. Used in feeding experiments from September 16, 1859, to February 1, 1860.

	Analyses.		
	I.	II.	Mean.
Water, ...	11·68	11·57	11·62
Albuminous compounds (flesh-forming matters), ...	11·72	11·72	11·72
Oil, fat and heat producing	5·96	5·94	5·95
Starch, materials,	35·86	35·81	35·84
Fibre (indigestible), ...	29·44	29·58	29·51
Ash (inorganic matter), ...	5·34	5·38	5·36
	100·00	100·00	100·00
Nitrogen, . . .	1·86	1·86	1·86

6. New toppings from oats (growth 1859), weighing 17·44 lbs. per bushel; price 4*s.* 6*d.* per 112 lbs. Used in the feeding experiments from September 16 to December 2, 1859.

	Analyses.		
	I.	II.	Mean.
Water, ...	9·64	9·42	9·53
Albuminous compounds (flesh-forming matters), ...	3·22	2·93	3·07
Oil, fat and heat producing	3·80	3·98	3·89
Starch, materials,	40·36	40·63	40·50
Fibre (indigestible), ...	39·90	40·02	39·96
Ash (inorganic matter), ...	3·08	3·02	3·05
	100·00	100·00	100·00
Nitrogen, . . .	0·513	0·467	0·49

Hay K, 2nd crop (growth 1859), clover and meadow grass, 13¾ cwt., at 6*s.* 2*d.* per cwt. Used in feeding from November 15 to December 14, 1859.

	Analyses.		
	I.	II.	Mean.
Water, ...	12·30	11·60	11·95
Albuminous compounds (flesh-forming matters), ...	5·98	6·33	6·16
Oil, starch, fat and heat pro-	1·66	1·48	1·57
sugar, &c., ducing materials,	33·00	33·73	33·36
Fibre (indigestible), ...	40·12	40·06	40·09
(inorganic matter), ...	6·94	6·80	6·87
	100·00	100·00	100·00
Nitrogen, . . .	0·952	1·008	0·98

100 grains of the hay K, which had been dried at 212° F., weighed 85·79 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F.; 14·21 per cent. of this hay were therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay, dried at 212° F.
Albuminous compounds, . .	6·99	5·80
Ash, ...	7·80	4·67
Fibre, ...	45·53	45·53
Oil, ...	1·78	29·79
Starch, ...	37·88	
	99·98	85·79
Amount of matter in this hay soluble in water, . .		14·21
		100 00

7. Moldavian round yellow Indian corn from Galatz, weighing 61½ lbs. per bushel; price, 34*s.* per 480 lbs. = £7 18*s.* 8*d.* per ton. Used from November 18, 1859, to February 1, 1860.

	Analyses. I.	Analyses. II.	Mean.
Water, ...	13·23	12·86	13·04
Albuminous compounds (flesh-forming matters), ...	8·58	9·24	8·91
Oil, fat and heat producing	4·54	4·58	4·56
Starch, materials,	66·59	66·16	66·38
Fibre (indigestible), ...	5·72	5·80	5·76
Ash (inorganic matter), ...	1·34	1·36	1·35
	100·00	100·00	100·00
Nitrogen, . . .	1·36	1·47	1·41

8. Irish rape-cake meal, 1½ cwt., at 7*s.* per cwt. Used in feeding from December 15, 1859, to February 1, 1860.

	Analyses. I.	Analyses. II.	Mean.
Water, ...	10·20	10·00	10·10
Albuminous compounds (flesh-forming matters, ...	32·24	31·36	31·80
Oil, fat and heat producing	11·30	10·64	10·97
Starch, materials,	14·98	16·86	15·92
Fibre (indigestible), ...	23·42	23·40	23·41
Ash (inorganic matter), ...	7·86	7·74	7·80
	100·00	100·00	100·00
Nitrogen, . . .	5·13	4·99	5·06

9. Toppings from Irish oats (growth of 1859), weighing 13 lbs. per bushel; price, 4*s.* per 112 lbs. Used from December 2, 1859, to February 1, 1860.

	Analyses.		
	I.	II.	Mean.
Water, ...	9·02	8·99	9·01
Albuminous compounds (flesh-forming matters), ...	2·20	2·20	2·20
Oil, { fat and heat producing	1·94	1·98	1·96
Starch, materials, }	24·90	24·37	24·63
Fibre (indigestible), ...	58·46	59·16	58·81
Ash (inorganic matter), ...	3·48	3·30	3·39
	100·00	100·00	100·00
Nitrogen, . . .	0·35	0·35	0·35

Hay L, 2nd crop, clover and mixed grasses, growth of 1859; 33 cwt., at 6*s.* per 112 lbs. Used in feeding from December 15, 1859, to February 1, 1860.

	Analyses.		
	I.	II.	Mean.
Water, ...	12·93	12·86	12·89
Albuminous compounds (flesh-forming matters), ...	5·27	5·85	5·56
Oil, starch, { fat and heat pro-	1·70	1·45	1·57
sugar, &c., ducing materials, }	24·32	25·60	24·97
Fibre (indigestible), ...	49·32	48·26	48·79
Ash (inorganic matter), ...	6·46	5·98	6·22
	100·00	100·00	100·00
Nitrogen, . . .	0·84	0·93	0·88

100 grains of the hay L, which had been dried at 212° F., weighed 84·93 grains after it had been digested in water for 24 hours, and subsequently dried at 212° F.; 15·07 per cent. of this hay was therefore soluble in water.

	Composition of the Hay not digested, but dried at 212° F.	Composition of the digested Hay, dried at 212° F.
Albuminous compounds, . .	6·38	6·34
Ash, ...	7·14	4·22
Fibre, ...	56·01	56·01
Oil, ...	1·80	1·58
Starch, sugar, &c., ...	28·67	16·78
	100·00	84·93
Amount of matter in the hay soluble in water, . .		15·07
		100·00

In Table I., I have calculated the mileage from known data: the return journey is not included in the calculation, as the horses simply returned with the empty carts.

The cost per single ton I have made out, as it shows at one glance whether it would be cheaper to employ horses, or to keep them. If we wish to employ horses, the charge is 1*s.* 8*d.* per ton; but, if we keep them, the cost is about 1*s.* 0¾*d.* per ton—viz., 7*d.* for the driver, 4¾*d.* for the food, and 1*d.* for repairs of harness, cart, and rent.

From this statement, it would seem that the keepers of horses had a direct profit of about 7¼*d.* per ton. Now, in reality, they have no such gain, as I have not, as may be perceived, noticed the depreciation in value of horses (which are bought young, and at a high price, and sold, after some time, at a reduced price), nor the interest of the money invested in the horses and carts.

In Table II., the quantities under the head *constant* are the amounts of albumen and carbon required to support the animal in idleness. What is given in excess of this quantity is expended in labour; and if not spent in the production of power, it goes to stock, or, in other words, is accumulated labour.

The constants were arrived at in the following manner:—From July 5 to Aug. 17, the horses consumed each per day 2·37 lbs. of albumen, and 8·41 lbs. of carbon, and carted out each per day 4·98 tons of goods. In the previous period, from May 24 to July 4, the horses consumed each per day 1·59 lbs. of albumen, and 6·88 lbs. of carbon, and carted out each per day 3·25 tons of goods. Now, if we deduct the tons and the albumen and carbon of the last-mentioned period—May 24 to July 4—from the first-mentioned period—July 5 to Aug. 17,—we obtain the difference in work and in the quantities of albumen and carbon consumed in the two periods. Thus:—

Tons.	Albumen.	Carbon.	
4·98	2·37	8·41. . . .	July 5 to Aug. 17.
3·26	1·59	6·88. . . .	May 24 to July 4.
1·72	0·78	1·53	

If the increased quantity, 1·72 tons, in the second period, requires 0·78 lbs. of albumen and 1·53 lbs. of carbon, 3·26 tons will require 1·47 lbs. of albumen and 2·91 lbs. of carbon. Now the difference between the quantities of albumen and carbon consumed per day in the period—May 24 to July 4,—and the quantities of albumen and carbon required by 3·26 tons per day—the work done in the period, gives us the quantity required by the animal in idleness:—

	Albumen.	Carbon.
	1·59 lbs.,	6·88 lbs.,
3·26 tons	1·47 ,,	2·91 ,,
Constants =	0·12 lbs.,	3·97 ,,

In that part of Table No. II. headed "Quantities," I have placed side-by-side the quantities of albumen and carbon required for the amounts of work placed before them, as found by experiment and by calculation. The quantities by experiment, with the *constants* added, give the actual quantities consumed. The calculated quantities, with the *constants* added, give the theoretical quantities.

In this Table, the experimental and calculated quantities agree very closely: there are but two periods where the difference is in any way large. This difference may be due to waste of food, in one case; and in the other, to the work being of a lighter kind.

As an additional proof of the constant quantities required for the animals' existence, and the quantities required for work, I have calculated the averages in Table No. II., and obtained the following results:—

If 3·26 tons require 1·47 lbs. of albumen, and 2·91 lbs. of carbon, 5·15 tons require

	Albumen.	Carbon.
By Calculation, ...	2·32 lbs.,	4·60 lbs.,
,, Experiment, ...	2·40 ,,	4·41 ,,
,, Average, ...	2·32 ,,	4·58 ,,

From this it is easy to perceive why the horses got thin; as on the average of the whole time, they required, by calculation, 4·60 lbs. of carbon, and got but 4·41 lbs., for each quantity of 5·15 tons of goods worked.

From these experiments, it appears that when food contains albumen and non-nitrogenous matters in the proportion of 1 to 8, or 1 to 10, it is best adapted for work-horses. When the albumen is in greater proportion than 1 to 8, there is a waste of it.

By these experiments and calculations, it appears that a horse requires per day in idleness about 64 oz. of carbon and 2 oz. of albumen; and as we give no food containing such a small proportion of albumen, the animal, although not gaining in fat, must gain in flesh or muscle.

The quantities of albumen and carbon required for each day's consumption is the sum of the *constants*, and the quantities required for work.

I have been told that the army horses get but 10 lbs. of hay and 10 lbs. of oats per day, both articles being of an inferior description. If this be true, it goes far to support my idea of a constant quantity.

Any discrepancies there may be between the experimental and calculated quantities may be accounted for by one or all of the following causes:—

1. Waste of food;
2. Inequality of roads travelled, with regard to incline and traction;
3. State of the weather; which lessens or increases traction, and, consequently, the labour.

TABLE No. I.

Dates.	Days.	Food per Day.				Totals.		Tons per Day.	Average Mileage per Ton.	Total Miles per Ton.	Cost per Ton, per Mile.	Cost per Single Ton.	Observations.
		Grain.	Cost.	Hay.	Cost.	Food.	Cost.						
		lbs.	Pence.	lbs.	Pence.	lbs.	Pence.				Pence.	Pence.	
May 24, to July 4,	42	14·25	10·60	14·94	6·80	29·19	17·40	3·26	2·56	8·35	2·08	5·34	No improvement nor deterioration.
July 5, to Aug. 17,	44	19·56	14·45	17·00	9·56	36·56	24·01	4·98	,,	12·75	1·88	4·82	Decided improvement.
Aug. 18, to Sep. 15,	29	18·62	15·20	20·43	11·10	39·05	26·30	6·36	,,	16·28	1·61	4·13	No change.
Sept. 16, to Nov. 3,	49	19·74	13·62	20·24	10·80	39·98	24·42	5·60	,,	14·34	1·70	4·36	Ditto.
Nov. 4, to Nov. 15,	12	21·11	14·08	18·66	9·83	39·77	23·91	5·13	,,	13·13	1·82	4·66	Ditto.
Nov. 18, to Dec. 1,	14	19·00	14·47	17·70	11·69	36·70	26·16	5·45	,,	13·95	1·87	4·80	Ditto.
Dec. 2, to Dec. 14,	13	20·46	15·15	17·70	11·69	38·16	26·84	6·33	,,	16·20	1·65	4·24	Ditto.
Dec. 15, to Feb. 1,	49	11·71	8·06	25·11	16·14	36·82	24·20	4·07	,,	10·42	2·32	5·94	Lost flesh; food deficient in carbon.
Averages, . . .	. .	. .	. .	. .	. .	. .	. .	5·15	. .	. .	1·86	4·78	

TABLE No. II.

Dates.	Constant.*		Tons per Day.	Quantities.				Food Grain.	Observations.
				Experiment.		Calculation.			
	Albumen.	Carbon.		Albumen.	Carbon.	Albumen.	Carbon.		
	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.		
May 24, to July 4,	0·125	3·975	3·26	1·47	2·91	1·47	2·91	Indian corn, bran, and oats.	There are but two periods where the discrepancy between the quantity of albumen, found by experiment and calculation, are any way large; this may arise, in the first instance, Aug. 17, to Sept. 15, from the work being light; and, in the second, from Nov. 18, to Dec. 1, from waste of food. From Dec. 15, to Feb. 1, the food was deficient in carbon, and the horses got poor. If the work for this period was calculated as per foot note, p. 10, there would be no discrepancy in the albumen quantities.
July 5, to Aug. 17,	0·125	3·975	4·98	2·24	4·44	2·24	4·44	Ditto.	
Aug. 18, to Sept. 15,	0·125	3·975	6·36	2·40	5·23	2·86	5·66	Indian corn and oats.	
Sept. 16, to Nov. 3,	0·125	3·975	5·60	2·70	5·67	2·52	5·00	Indian corn, bran, and toppings.	
Nov. 4, to Nov. 15,	0·125	3·975	5·13	2·23	5·68	2·31	4·57	Indian corn and toppings.	
Nov. 18, to Dec. 1,	0·125	3·975	5·45	2·88	4·49	2·46	4·85	Indian corn and bran.	
Dec. 2, to Dec. 14,	0·125	3·975	6·33	2·76	4·67	2·85	5·64	Indian corn, bran, and toppings.	
Dec. 15, to Feb. 1,	0·125	3.975	4·07	2·55	2·19	1·83	3·62	Indian corn, bran, toppings, and rape cake.	
Averages, . . .	. .	. .	5·15	2·40	4·41	2.32	4·58	5·15 tons × 2·56 miles = 1 ton 13·18 miles. The cartage of 1 ton, 1 mile, would cost 2·91. oz. of albumen, and 5·60 oz. carbon.	

* These are the quantities required to support the animal in idleness.

XVIII.—Brief Notices of a Botanical and Horticultural Tour made through portions of Germany, Holland, and Belgium, in the Autumn of 1860. By D. Moore, F. L. S., &c., Curator of the Botanic Garden.

[Read before the Royal Dublin Society, on Monday, January 23, 1861.]

In giving the following brief notices on matters of botanical and horticultural interest, connected with a tour I made last autumn through portions of some Continental countries, I shall be better able to connect the details by simply following the route taken on that occasion. Leaving Hull by steamer for Hamburgh, the Elbe was reached after experiencing a very rough passage of two nights and three days' duration. The shores of that important river, as seen at a distance when passing along in the steam-vessel, do not appear very inviting to inhabitants of undulating countries. Both Danish and Hanoverian sides are low, rising very little above the bed of the river; and the consequence is, that extensive reaches of strong-growing aquatic plants form broad margins along the banks for many miles together, occasionally extending a considerable distance inland. The principal sorts appeared to be our common bullrush, *Scirpus lacustris*, *Scirpus maritimus*, and the ubiquitous reed grass, *Phragmites communis*, all of which are useful plants in those countries. Their creeping roots bind the loose soil firmly on the banks of rivers, canals, &c., and thereby prevent it from being washed away by the agitated waters. They are also of some value in an economic point of view, as the bullrush is there manufactured into various articles of furniture, which is also the case in this country. After Cruxhaven is passed, the country appears to improve, both in fertility and cultivation, with many comfortable-looking farm-buildings visible, until Hamburgh is approached, when the Danish side becomes particularly picturesque. A series of undulating hills, with fertile valleys intervening, line the shore for several miles, the faces of which are thickly covered with handsome villas, many of them on a scale of splendour seldom seen near Continental cities.

My first visit after arriving was to the Botanic Garden, which is situate in the immediate vicinity of the city. The Inspector, M. Otto, received me with much cordiality; and Saturday being a leisure day with him, he kindly proposed to accompany me to some of the best plant gardens and nurseries in the neighbourhood, which I gladly agreed to. We accordingly went to the villa residence of M. Schiller, near Altona, who possesses one of the best private collections of plants I know of anywhere. I question much if there be one in England to surpass it, either for extent, value of plants, or high state of culture they present. The proprietor was in Switzerland at the time; but his gardener, M. Stange, conducted us through the numerous conservatories, where I observed many rare plants, among which were several I had not previously seen.

One large house was wholly occupied with the best sorts of variegated-leaved Begonias, and a few other conspicuous plants interspersed among them, the whole forming quite a picture of beautiful foliage, as well as a perfect specimen of good cultivation. The following named sorts were rather remarkable among the mass:—*Madam Schiller*, *Bossier*, *Prince Troubetskoy*, and *bullata*. Not a decaying or blotched leaf was visible on one of them, which is rarely the case in groups of this sort; and on considering the matter afterwards, it occurred to me the perfection they were in might be partly owing to the conservatory being roofed with double sashes, which would prevent the external moisture from entering so readily, as well as the internal vapour from condensing, so as to fall in drops from the roof. Among the orchids were many rare kinds, and I have seldom seen so large a number in bloom in one establishment at the same time. Four, if not five, species of *Phalænopsis* were flowering, and among them the rare *Phalænopsis Schilleriana*, which I had not previously seen; another curious plant, named in honour of the same gentleman, viz., *Silenopodium Schilleriana;* also, *Miltonia Regnelia*, *Masdevalia maculata*, *Epidendrum glumaceum*, *Pescatorea cornuta*, *Dendrochilum arachnoideum*, *Trichopilia suavis*, *Stanhopia ecornuata*, &c. The species of *Vanda*, Aerides, and Saccolabium, were both numerous and fine.

Our next visit was to the extensive nursery establishment of the Messrs. Booth, through which one of the gentlemen kindly accompanied us. These nurseries are well known and famed through most parts of Europe, for extent of ground occupied, great collections of hardy and tender plants, as well as for the manner they are conducted. The collections of ferns, orchids, and cacti were good, and comprised a number of rare kinds. There were also some of the best plants of *Nepenthes sanguinea* I have seen, along with such other sorts of pitcher plants as are only found in a few nurseries. The assortment of hardy ornamental trees is extensive; and although many having distinct nursery names are only varieties of well-known species, they are different in their appearance, and interesting as such. I observed good plants of *Quercus lyrata*, *Quercus pubescens*, *Quercus coccinea*, variety *dissecta; Tilia Europæa*, variety *asplenifolia*, and variety *spicata; Cerasus Mahaleb*, variety *monstrosa*, *Cerasus asplenifolia*, *Caragana jubata*, *Robinia revoluta*, *Salisburia adiantifolia*, variegata, *Cercis siliquestrum variegatum; Morus macrophylla*, *Morus urticifolia*, *Fraxinus discolor*, weeping walnut, and weeping thorn, along with many others still rare in this country. A handsome specimen of the weeping deciduous cypress, *Taxodium distichum*, variety *pendulum*, stood near Mr. Booth's residence. It was of a pyramidal form, and about twenty feet high, well clothed with branches. Another pretty tree, much used for ornamental purposes through the North of Germany, stood near the cypress, the upright variety of elm, known under the name of *Ulmus oxoniensis.*

By appointment I again met M. Otto at the Botanic Gardens, for the purpose of making lists of plants for exchange, and where I found an extensive collection of both hardy and tender kinds. The ranges of conservatories, though such as would be considered clumsy in England, are rather extensive, and probably well suited for affording protection to plants where the climate is rigorous during winter. Some fine specimens of Cycadaceous plants occupied places on their benches at the time I visited, and also a number of good palms. The tropical aquarium, in which plants of *Victoria regina* are cultivated, is a commodious structure, and the collection of stove aquatics numerous, particularly in species of Nymphæa, some of which were then in flower. The herbaceous plants are arranged according to the Linnean system, and rather extensive. Although much frequented by the inhabitants of Hamburgh, and sales of plants made to support the funds, still the scientific character of the garden is well kept up, whilst the more ornamental department is not neglected.

Taking leave of my kind friend Otto, I went by rail to Berlin, which, for the most part, passes through a series of extensive flat, sandy plains. From the windows of the carriage I could observe several plants which are either strangers to the British Flora, or rarely met with in this country. The sandy banks in many places were yellow with the flowers of *Helichrysum arenarium;* and *Cichorium Intybus,* with *Gentiana Pneumonanthe,* are also common plants there. Among the cultivated crops was one I had not previously seen, namely, the succulent yellow lupin, *Lupinus succulentus,* which is grown extensively in some parts of Germany, and appears to delight in the poor sandy soils on which it is generally cultivated. The appearance produced by the golden yellow flowers of this plant in such masses is very beautiful. It then occurred to me that this lupin might prove of considerable value for cultivating on the light sandy soils which abound so extensively in many parts round the sea-board of this country, and are now producing little else except bent. At any rate, it would surely be worth a trial; but in doing so, the seeds would require to be sown early, after the frosts have passed, in order that the plants may have all the advantage of the growing season; for when experimenting on crops which grow well on the Continent, it ought to be kept in view that although the mean annual temperature of those countries may be only equal to that of our own, the heat there is much greater during summer than it is here, and the winters colder. On making further inquiry about the lupin crop, I learned that the farmers grow it in many instances for the purpose of ploughing it in green as manure into the land, on which other crops are to be raised.

At the Berlin Botanic Garden I was politely and kindly received by the Inspector, M. Bouché, who conducted me though the establishment, and enabled me to make memoranda for exchange of plants, which has since been effected. One of the principal objects of attraction in this garden is the great new palm-house, which was lately built, and is now occupied with fine plants. It is 170 feet long by 54 high and 50 wide, covered with ridge and furrow roof in double sashes. It is heated by both steam and hot water. The former is generated from boilers placed underground, and chiefly used for the purpose of supplying bottom heat to the plants, the largest of which are placed on hollow pillars to which the steam has access. It can also be admitted to the body of the house through apertures, so as to render the atmosphere as moist as a vapour bath, or shut off at pleasure by closing the apertures. Judging from the appearance of the plants, they like the treatment they are subjected to. Long adventitious roots were, in many instances, protruding from the stems of some palms, and many species of other plants; thus affording proof of the damp atmosphere they are grown in. It would be impossible, as well as undesirable, in a brief notice like the present, to mention a tithe of the old and interesting plants to be observed in the Berlin collection. I shall, therefore, confine my observations to a few of the more remarkable kinds. The number and size of the tree ferns are features most likely to attract the notice of English visitors; and the following rough measurements of a few will give some idea of their dimensions:—*Cyathea aurea*, with stem about 20 feet high; *Hemitelia integrifolia*, stem 5 feet; *Alsophila obtusa*, stem 15 feet, with several others of great size, among which are *Alsophila inermis, Angiopteris longifolia, Pteris castaneanus, Diplazium grandifolium*, and *Cyathea Mexicana*. Next in interest, according to my estimation, were the numerous species of Pandanæ, some of which form such grotesque figures when large. *Pandanus utilis* was full of fruit, which are singular looking black globular masses; and *Pandanus furcatus* was also in flower, as were some of the species of *Cyclanthus* and *Carludovica*. Some of the palms are already noble specimens, and not a few rare kinds among them. A large species of *Strelitzia*, resembling *Strelitzia augusta*, but said to be different from it, I had not previously seen. It is there called *Strelitzia Nicolai*, and came from the Botanic Garden at St. Petersburgh to the Berlin garden. Another remarkable plant was a large species of bamboo cane, *Bambusa latifolia* of *Kunth*. The leaves of this cane are nearly 6 inches wide, and the canes much stronger than those of the plant generally cultivated in British collections. The Agave tribe of Amaryllidaceous plants, which are so great favourites on the Continent, are well represented at Berlin, and some fine specimens among them. There is also a good collection of the globular-formed cacti, so well known from the figures published of many of these by Dr. Pfeiffer and the late Inspector Otto. The hardy trees are neither very numerous nor large, but I observed a good species of poplar among them, which I am not aware has yet been grown in Ireland. It is there called *Populus laurifolia*, and forms a tree 60 feet high, with large shining leaves.

The next garden I visited in the neighbourhood of the Prussian capital was that of M. Borsig, at Moabit, where there is a fine private collection of plants, the grand feature there being the amazing number of tropical aquatic plants cultivated in the open air. This is effected by supplying a winding stream, which passes through the garden, with a constant flow of hot water from the adjoining iron works. This stream is about 100 yards long by 20 wide, and is filled with them. The gardener, M. Goerds, informed me that only three years ago a single plant of *Nelumbinum speciosum* was planted, which has already spread itself over a great portion of the stream; and on the day I visited, there could not have been fewer than one hundred expanded blooms of this loveliest of flowers. At the same time there were many flowers of *Victoria regia*, *Nymphæa Devoniana*, *Nymphæa cœrulea*, *Nymphæa dentata*, &c., altogether producing such a charming floral picture as can hardly be imagined. Near the aquatics stood another interesting group of tender coniferous plants, among which were *Araucaria excelsa*, *Araucaria Cunninghami*, *Dacrydium Cupressinum*, some species of Dammara, &c. They were planted out in the open ground, and are covered in winter with a moveable conservatory. Their appearance in that state was so unlike that they have when starved in small pots or tubs, as scarcely to be longer recognisable as the same kinds of plants. In the extensive range of conservatories were some good specimens of palms, tree ferns, and orchids, most of which presented the appearance of rude health.

From Berlin I went to Potsdam, to see the terraced gardens, &c., at Sans-souci, which are a curiosity in their way. There are seven tiers of terraces rising one above the other, each of which is faced by a brick wall, which walls are occasionally covered with glazed sashes, according as the crops of figs, grapes, peaches, &c., require protection. A number of large and among them curious forms of gourds were lying on the walks, attached to the vines, which were planted on the borders, and allowed to trail over some parts of the walks, producing a pleasing effect on the terraces.

In Germany fine foliage appears to be more prized than mere showy flowers, in which respect the art of flower gardening differs materially there from the manner it is practised in England. At Sans-souci, the beds on the grass were filled with such plants as the dwarf fan palm, *Chamærops humilis*, *Caladiums*, and *Cannas* of sorts; and even our common rhubarb found a place among the number, and played no mean part as an ornamental plant. In other beds the large grass *Arundo donax*, with varieties of Indian-corn plants, formed good contrasts to those which were occupied with Pelargoniums, &c. To the eye of an English gardener, who cultivates twenty kinds of scarlet Pelargoniums, each differing slightly in colour of flower and in foliage, with twice that number of shades of colour among his beds of verbenas, such plants as I have stated will no doubt appear coarse and incongruous; but let the two methods be placed before the eye of a good landscape painter, I can readily opine which he will choose.

The new orangery, which is I dare say by the time I write finished, is on a surpassing scale of magnitude. It is 1000 feet long, by 45 wide and 25 high. In general appearance, it seems a massive heavy building, with pillars of cut stone along the front, between the upright sashes; and at the back part there is a sort of gallery, raised about 8 feet above the level of the floor. I believe it is intended for a winter promenade for the officers of the household, &c., as well as for sheltering plants. In front, new terraced flower gardens have been commenced, which will ultimately have a magnificent effect, if carried out on a scale commensurate with the great conservatory.

Near Sans-souci is the extensive nursery collection of M. Fricke, at Augustin, where, I believe, the largest quantity of palms are cultivated for sale which is to be found in any single establishment in Europe at the present time. One large range of conservatories, about 400 feet long, was mostly filled with palms and ferns, and other smaller houses with many very rare plants. This collection seemed to me to bear a greater resemblance to that which the Messrs. Loddiges, at Hackney, had twenty years ago, than any other I have seen, and the prices asked were very reasonable. A large plant of *Dasylirion acrotriche* was then in flower, this being the first time I had seen this species blooming.

From Prussia I went to Hanover by rail, which enabled me to get a railway view of the agricultural crops along the line. The country from Berlin to Magdeburgh appeared to be mostly of a light sandy nature, and in many instances had a barren look; but the numerous fields of *Lupinus succulentus* in full bloom produced there, as elsewhere, a warm and pretty effect. After Magdeburgh is passed, the country improves in fertility and cultivation until Brunswick is reached, in the neighbourhood of which I observed large fields of mangel, carrots, rape, and gold of pleasure, *Camelina sativa*, ripening into seed, this being a part of Germany where those crops are largely cultivated for supplying the seed market. Soon after arriving in Hanover, I visited the fine old botanical garden at Herrenhausen, where I was speedily joined by the Director, M. Wendland, to whom I carried a letter of introduction from a friend in England.

The grand feature of this garden is the great collection of palms, for which it has long been famous; it is also rich in species of Pandaneæ and Cycadeæ. The principal palm-house is said to be 120 feet long, by 40 high, and 30 wide. The most remarkable plant in it is a magnificient specimen of *Corypha australis*, which has a clean stem for 14 feet, measuring 6 feet in circumference at the base, and had on it, at the time I saw it, 114 full-grown leaves. There were also good plants of *Manicaria Saccifera*, *Geonoma electropus*, *Areca aurea*, *Areca Verchaffelti*, *Iricartea gigantea*, *Morenia gigantea*, *Frecynetia insignis*, *Frecynetia rubra*, *Pandanus latissimus*, *Pandanus sessilis*, *Macrozamia eriolepis*, *Macrozamia Skinneri*, *Lechtenbergia princeps*, &c., &c., some of which I expect to get in return for plants I sent to M. Wendland last autumn. A rather extensive flower-garden in front of the Royal Palace has lately been laid out in the French style, which I had not time to look minutely through; but my attention was arrested on seeing a large tree of *Sophora japonica* in full bloom, which does not flower in Ireland that I am aware of, though it grows so freely. The fine avenue leading from the town of Hanover to the Botanic Garden is straight from one end to the other, and between one and two English miles in length. On each side are several lines of old lime trees, planted at equal distances, which extend the whole of the way, thus affording shade and shelter to the inhabitants, who so much frequent the avenue and park. The journey from

Hanover to Amsterdam was performed by night train, which prevented my seeing much of the agricultural crops until Oberhausen was reached. From thence on to Utrecht, the country through which the line of railway passes, presents a rather wild and barren aspect, and although nearly level, is considered the highlands of Holland. Extensive tracts of sandy heath land, covered in some places with dense woods of Scotch fir, with canals and ditches standing full of water, appear to be characteristic features of that portion of country. From Utrecht until Amsterdam is reached, is nearly one vast level plain, intersected by canals, with extensive grazing fields, covered with herds of black cattle, having a few white patches on each, but so like in colour, that one scarcely differs from the other.

The Botanic Garden at Amsterdam is small, but contains a number of good plants, and is especially rich in cycadeæ. M. Groenewegan, the Inspector, kindly conducted me through the conservatories, and pointed out anything of special interest, among which were the following cycads:—*Cycas inermis* (female plant in fruit); *Cycas circinalis*, fine; *Cycas Rumphii* (female plant); *Cycas Altensteinii*, large; *Encephalartos caffra*, with clean stem 12 feet high; *Encephalartos Lehmanii*, fine; and *Encephalartos cycadifolia*, new, and fine. There were also some of the pretty variegated-leaved orchids not often found in collections, particulary *Pogonia discolor*, and *Goodyera colorata.* I also went to see M. Willink's collection, near Amsterdam, which is rich in tree ferns, and many of them fine specimens. *Dicksonia chrysotricha*, *Alsophila contaminans*, *Alsophila senilis*, *Alsophila subacaulis*, *Alsophila compta*, *Lophosora affinis*, *Ciboticum Cummingi*, *Angiopteris hypoleuca*, *Marattia Willinki*, and *Hermionitis Blumeii*, were all in large-sized plants. From this point I visited the far-famed Bulb gardens, at Haarlem, and there spent a day among them. Previous to this, I had not formed a correct idea of the soil on which our beautiful Hycinth roots, Tulips, Polyanthus, Narcissus, Gladioli, &c., &c., are so extensively produced. It is almost pure sand, with a slight mixture of the debris of alluvial clay. Our Dublin Hyacinth-growers might form a very good notion of the position those gardens occupy, by supposing the little town of Baldoyle, near Howth, to be Haarlem, with Portmarnock sand-hills between it and the sea, preventing the farther encroachment of the waves, and the small farms inside the sand-hills the Bulb Gardens. Under this supposition, the localities are similar; but here we want the greater heat in summer, besides another important desideratum which we cannot supply, namely, plenty of moisture at a short depth from the surface during the dry season, when the plants are growing vigorously, and forming their bulbs. At Haarlem the ground is intersected by canals and deep ditches at every 100 yards or so, from which the water percolates at its level, and supplies the plants with plenty of moisture at the period of their growth when it is specially required. With this soil large quantities of cow manure is mixed, on which the bulbs are planted; but I could not learn that any other particular manipulation was resorted to, further than to keep the ground clear of weeds.

We can form very little idea respecting the extensive scale those plants are cultivated on, until we have actually seen it. Large squares of Polyanthus, Narcissus, and Crocuses had already been planted in September, when immense quantities of hybrid Gladioli were in bloom. The Messrs. Rosenkrantz kindly conducted me through their drying and saving houses, where the remaining portion of their bulbs were spread out on airy shelves; but the greater part of them had been despatched before that time to the English and Russian markets, where the principal consumption takes place. Haarlem is on the same line of rail to Leyden, where I went to see the old Botanic Garden, so famous in early European botanical history, in connexion with the names of Linnæus, Clusius, and other eminent botanists during the past and present centuries. On a tablet there is the following quaint epitaph to Clusius:—

"*Non potuit pluris quarere, Clusius herbas ergo novas campis quaerit in Elysis.*"

A few of the old trees planted by Linnæus were pointed out by the present Inspector, M. Witté, who kindly accompanied me. The garden is yet well kept up, and contains a fair collection of botanical plants, both tender and hardy, some of which are rare species. In the Orchid-house I observed plants of *Phalænopsis zebrina*, *Cyprepedium caudatum*, *Cyprepedium hirsutissimum*, *Lycopodium phlegmaria*, and *Lycopodium furcatum*. Among the hardy trees outside, there is the largest one of *Salisburia adiantifolia* I had previously seen, which must have been among the earliest planted of its kind in Europe. It is now almost 60 feet high, with a stem 6 feet in girth. There are also large specimens of *Gleditchia horrida*, and *Catalpa Kæmpferi*. The herbaceous plants are arranged according to Endlicher's system, and appeared to comprise a good collection. The Haguo and Rotterdam were next visited, but I could not learn there was much of particular interest in the way of botanical or horticultural gardens near them. I therefore devoted all the time I had to spare in visiting the principal picture galleries, and zoological garden at Rotterdam; when, after looking though those curious old towns, I passed on to Antwerp.

Having previously made some acquaintance with M. Charles Van Geert, I went first to see his nursery, which is well worthy of a visit from lovers of ornamental plants. Selections of most of the trees and shrubs which stand hardy in Europe are to be found in this nursery, as well as fair collections of hardy green-house, and herbaceous plants. Among them, I noticed good plants of *Acer palmatifida*, *Acer pseudo-platanus purpurea*, *Robinia inermis pyrimadalis*, *Pavia Californica*, *Quercus nigra*, *Quercus macrocarpa*, *Juglans lacerata*, *Castanea dissecta*, *Tilia Mississippiensis*, *Ulmus Dampieri*, *Cornus mascula variegata*, *Populus pendula variegata*, &c., &c.

In the neighbourhood of this nursery is the residence of Madam le Grele, who possesses an extensive private collection of good plants; but what I wished particularly to see there was the large specimen of *Theophrasta imperialis*, which is certainly a magnificent plant. Its dimensions are in height about 12 feet, in diameter about 6 feet, and well covered with healthy foliage, each leaf from 2 to 3 feet long.

My next stage was Ghent, where I visited the fine nurseries of M. Van Houtte, M. Verchaffelt, and M. A. Van Geert, all of which are well known to most plant-growers in England and Ireland through their advertisements and catalogues, which are annually issued, as well as from personal visits. Having noticed them in detail on a previous occasion, I need not allude to them more particularly at present, further than to say, I deem it a treat of no ordinary kind to be allowed to inspect those splendid collections of plants, especially when accompanied by the polite and highly intelligent proprietors of them. Leaving Ghent, I reached England, *via* Ostend, after a most agreeable and profitable tour.

N.B.—The writer of the foregoing notes begs it may be fully understood that he does not in any way hold himself responsible for the names of the different plants mentioned being in all cases correct, or even such as they are at present known by in England. They were either taken from labels attached to the plants, or orally communicated by the gentlemen who accompanied him through the different establishments; and consequently have been adhered to, with a view of facilitating correspondence, as the plants are known at the different gardens and nurseries by the names he has given.

XIX.—ON THE COMPOSITION OF DUBLIN PORTER. By GEORGE W. JACKSON, B. A., and WILLIAM J. WONFOR, Students in the Laboratory of the Museum of Irish Industry.

[Read before the Royal Dublin Society, on Monday, December 17, 1860.]

A WANT has often been felt by medical men, and others, in Dublin, interested in the composition of such substances, of a reliable and complete analysis of Irish porter; for although the composition of the principal English and foreign beers has been determined by different chemists, no such investigation had hitherto been undertaken in Dublin. At the suggestion of Professor Galloway, Mr. Jackson undertook the analysis of Guinness's XX porter; but at an early stage of the proceedings being obliged by ill health to forego the completion of the research, the task devolved on me to finish it; and we have much pleasure in laying before the Royal Dublin Society the results of our joint investigation. The sample of porter which we employed was obtained from Mr. Edward Burke, of Middle Abbey-street, agent to the Messrs. Guinness; and the analysis was performed in the laboratory of the Museum of Irish Industry, under the direction of Mr. Galloway.

The different determinations were made in the following manner:—

1000 grs. by measure were evaporated to dryness in a water bath, and the residue then dried at a temp. of 212° F. until it ceased to lose weight: this gave the amount of solid matter. The ash was obtained by burning the residue, which being deducted from the total quantity of solid matter, gave the amount of organic matter.

By a careful qualitative examination of the ash, silica, lime, phosphate of magnesia, potash, soda, hydrochloric, phosphoric and sulphuric acids, were discovered.

The ash was treated with hydrochloric acid; the insoluble portion collected on a tared filter, dried at 212° F.; washed, and again dried, and weighed; this gave the quantity of charcoal and silica. The filter and insoluble matter were then incinerated, and the inorganic matter weighed, after deducting the weight of the filter ash, and subtracting the remainder from the total insoluble residue; this gave the amount of charcoal.

The filtrate, together with the wash water from the insoluble residue, were collected in a flask capable of holding 20,000 grains by measure of liquid, which was then made up to the mark with distilled water.

Two estimations were made of all the constituents, with the exception of the insoluble residue, in order to insure accuracy; 7000 grs. of the solution being employed.

Acetic acid was added to the solution, and the lime then precipitated by the addition of oxalate of ammonia, and estimated as carbonate in the usual manner.

The filtrate was concentrated by evaporation, and ammonia then added in excess, to precipitate the phosphate of magnesia, which was collected on a filter, washed with ammonia water, dried, ignited, and weighed.

The filtrate from the phosphate of magnesia was concentrated, and a clear mixture of solutions of chloride of ammonium, ammonia, and sulphate of magnesia added, and the whole allowed to stand for twelve hours in the cold; it was then filtered, the precipitate washed with ammoniacal water, and weighed as pyrophosphate of magnesia, from which the amount of phosphoric acid was calculated.

The filtrate from the phosphoric acid precipitate was evaporated to dryness, and ignited, in order to expel ammoniacal salts; the residue was dissolved in water, baryta water added to the solution, and the precipitate which contained the magnesia and sulphuric acid was collected on a filter, and washed; carbonate of ammonia was then added to the filtrate to separate the excess of baryta, and the filtrate from the carbonate of baryta which contained the alkalies again evaporated to dryness, and ignited; the residue was dissolved in water, hydrochloric acid added; and the solution evaporated to dryness in a weighed crucible; the residue was ignited, and the mixed alkalies weighed as chlorides; the potash was then separated from the soda, by the addition of bichloride of platinum; the precipitate, being collected on a dry filter of known weight, was dried in an air bath at a temperature of 212° F., and estimated as potassio-bichloride of platinum.

3000 grains of the solution were employed for the estimation of the sulphuric acid; chloride of barium was added, and the precipitate collected on a filter, washed, ignited, and weighed as sulphate of baryta.

A portion of the ash was dissolved in pure nitric acid, and nitrate of silver added to the solution to precipitate the hydrochloric acid; the precipitate was washed by decantation, collected on a filter, dried, ignited, and weighed as chloride of silver.

For the determination of the nitrogen, 1000 grains by measure of the porter were evaporated to dryness, the nitrogen in the residue being converted into ammonia by combustion with soda lime; but, on account of the adhesiveness of the residue, it was found necessary to mix the porter with carbonate of lime before evaporation, care being taken that not the slightest trace of ammonia existed in the carbonate. The ammonia formed during the process was, in one estimation, collected in a solution of hydrochloric acid, and the quantity of acid which remained unneutralized was estimated as ammonio-bichloride of platinum—and in the other estimation it was collected in a standard solution of sulphuric acid, and estimated by a standard solution of ammonia. The nitrogen was calculated as albumen, on the assumption that 15.92 parts of nitrogen are equal to 100 parts of albumen.

The spirit was estimated in Phillips' distilling apparatus; 2000 grains by measure of the porter were employed, and about two-thirds of the quantity distilled over, the distillate was made up to 1600 grains with distilled water, and the specific gravity taken by the sp. gr. bottle at the temperature of 60° Fahr.; from this was calculated the amount of spirit in 1000 parts.

To the residue, which remained in the flask after the distillation of the spirit, was added, when cold, 150 grs. of yeast, and the mixture kept at a temperature of about 80° Fahr. for about twenty-four hours, care being taken to connect the flask in which the fermentation was carried on with the condenser, so that any alcoholic vapour which might be exhaled during the fermentation should not be lost; when the fermentation had entirely ceased, heat was applied to the flask to distil off the alcohol, about two-thirds of the liquor was distilled over, and the distillate collected in a cooled receiver, and made up to 1600 grs., the specific gravity was then taken by the sp. gr. bottle. To obtain a correction for the small quantity of alcohol introduced by the yeast, a parallel experiment was made with that substance; the same weight of yeast was mixed with water, and distilled in a similar flask; the distillate was made up to the same volume as the preceding, and the specific gravity taken. The quantity of absolute alcohol by weight in the two liquids was calculated from the specific gravities, and the amount in the yeast deducted from the total amount: this gave the quantity of alcohol due to the porter, and from this the quantity of grape sugar was calculated.

The sugar and albumen were then deducted from the total amount of organic matter, and the difference gave the amount of extractive matter.

The acetic acid was estimated by adding to 2000 grs. of the porter a standard solution of ammonia until all the free acid was neutralized.

First Analysis.

SPECIFIC GRAVITY OF THE PORTER, 1019·565.

Estimation of the alcohol :—

2000 grs. by measure of the porter gave,—
1600 grs. of a spirit having a sp. gravity of 991·2 at 60° Fahr.
= 179·2 grs. of proof spirit in the 2000 grs. of porter.
= 89·6 grs. of proof spirit in 1000 grs. by measure of porter.

Estimation of the sugar :—

The residue from the distillation of the spirit gave, after being fermented with

150 grs. of yeast, 1600 grs. of a spirit having a sp. gr. of 999·37 = 5·68 grs. by wt. of absolute alcohol in the 1600 grs. of spirit.

150 grs. of the yeast when distilled yielded 1600 grs. of a spirit having a sp. gr. of 999·59 = 4·08 grs. by weight of absolute alcohol in the 1600 grs. of spirit, 5·68 – 4·08 = 1·6 grs. by weight of absolute alcohol = 3·44 grs. of grape sugar (C_{12}, H_{11}, O_{11}, 3 HO) = 1·72 grs. of grape sugar in 1000 grs. of porter.

Estimation of acetic acid :—

2000 grs. by measure of the porter required,—
120 grs. of a stand. solution of ammonia (1 eq. in 1000 grs.) =
7·2 grs. of acetic acid.
= 3·6 grs. of acetic acid (C_4 H_3 O_3, HO.) in 1000 grs. of porter.

Estimation of albuminous compounds :—

1000 grs. by measure gave 1·317 grs. of nitrogen.—
= 8·272 grs. of albumen,

Estimation of solid residue, organic and inorganic :—

1000 grs. by measure gave 71·732 grs. of solid residue, which yielded 4·166 grs. of inorganic matter (ash),
71·732 – 4·166 = 67·566 grs. of organic matter,

Estimation of chlorine :—

12·149 grs. of ash gave 3·208 grs. of AgCl., =
= 0·793 grs. of Cl. = ·272 grs. in 1000 grs. of porter.

Estimation of sulphuric acid :—

7·877 grs. of ash gave 1·529 of BaO, SO_3,
= ·525 of SO_3 = ·277 in 1000 grs. of porter.

Estimation of Silica :—

28·721 grs. of ash gave 2·047 of insoluble residue, which contained ·048 of charcoal, and 1·999 of silica; therefore 28·721 – ·048 = 28·673, the quantity of inorganic matter employed.

1·999 of silica in 28·673 of ash = ·290 in 1000 grs. of porter.

Estimation of lime:—

10·035 grs. of ash gave ·367 of CaO, CO_2.
= ·205 of CaO = ·085 in 1000 grs. of porter.

Estimation of phosphate of magnesia:—

10·035 grs. of ash gave 2·052 of 2MgO, PO_5.
= ·851 grs. of phos. mag. in 1000 grs. of porter.

Estimation of phosphoric acid:—

10·035 grs. of ash gave 2·595 of 2MgO, PO_5,
= 1·66 of PO_5 = ·690 in 1000 grs. porter.

Estimation of the alkalies:—

10·035 grs. of the ash gave 6·44 of the mixed chlorides;
6·44 grs. of the mixed chlorides gave
19·04 grs. of Pt Cl_2, KCl = 5·82 of KCl.
6·44 − 5·82 = ·62 of NaCl.
5·82 of KCl = 3·677 of KO.
0·62 of NaCl = ·33 NaO,
= 1·527 of potash in 1000 grs. of porter,
= 0·273 ,, soda in 1000 grs. of porter.

Second Analysis.

SPECIFIC GRAVITY OF THE PORTER, 1019.200.

Estimation of the alcohol:—

2000 grs. by measure of the porter gave
1600 grs. of a spirit having a sp. gr. of 990·967 at 60° Fahr.,
= 184 grs. of proof spirit in the 2000 grs. of porter,
= 92 grs. of proof spirit in 1000 grs. of porter.

Estimation of the sugar:—

The residue after the distillation of the spirit gave, after being fermented with 150 grs. of yeast,
1600 grs. of a spirit, having a sp. gr. of 999·37,
= 5·68 grs. by weight of absolute alcohol in the 1600 grs. of spirit.
150 grs. of the yeast when distilled yielded 1600 grs. of a spirit, having a sp. gr. of 999·59 = 4·08 grs. by weight of absolute alcohol in the 1600 grs. of spirit,
5·68 − 4·08 = 1·6 grs. by weight of absolute alcohol
= 3·44 grs. of grape sugar (C_{12}, H_{11}, O_{11}, 3 HO),
= 1·72 ,, ,, ,, in 1000 grs. of porter.

Estimation of acetic acid:—

2000 grs. by measure of the porter required
120 grs. of a standard solution of ammonia (1 eq. in 1000 grs.),
= 7·2 grs. of acetic acid (C_4, H_3, O_3, HO),
= 3·6 grs. of acetic acid in 1000 grs. of porter.

Estimation of albuminous compounds :—

1000 grs. by measure gave 1·2 grs. of nitrogen,
= 7·5 grs. of albumen,

Estimation of solid residue, organic and inorganic :—

1000 grs. by measure gave 70·696 grs. of solid residue, which yielded 4·27 grs. of inorganic matter (ash),
70·696 – 4·27 = 66·426 grs. of organic matter.

Estimation of chlorine :—

15·180 grs. of ash gave 4·037 grs. of AgCl.
= ·998 grs. of chlorine = ·274 grs. in 1000 grs. of porter.

Estimation of sulphuric acid :—

4·308 grs. of ash gave ·833 grs. of BaO, SO_3,
= ·286 grs. of SO_3 = ·274 in 1000 grs. of porter.

Estimation of Silica :—

28·721 grs. of ash gave 2·047 of insoluble residue, which contained ·048 of charcoal and 1·999 of silica, therefore 28·721 – ·048 = 28·673, the quantity of inorganic matter employed.
1·999 of silica in 28·673 of ash = ·290 in 1000 grs. of porter.

Estimation of lime :—

10·035 grs. of ash gave ·367 of CaO, CO_2,
= ·205 grs. of Ca O = ·085 in 1000 grs. of porter.

Estimation of phosphate of magnesia :—

10·035 grs. of ash gave 2·063 of 2MgO, PO_5,
= · 856 grs. of phosphate of magnesia in 1000 grs. of porter.

Estimation of phosphoric acid :—

10·035 grs. of ash gave 2·649 of 2MgO, PO_5,
= 1·694 of PO_5 = ·703 in 1000 grs. of porter.

Estimation of the alkalies :—

10·035 grs. of the ash gave 6·394 of the mixed chlorides,
6·394 of the mixed chlorides gave
18·975 grs. of Pt Cl_2, KCl = 5·73 of KCl,
6·394 – 5·73 = ·664 of NaCl,
5·73 of KCl = 3·62 of KO,
·664 of NaCl = ·35 of NaO,
= 1·50 grs. of potash in 1000 grs. porter,
= ·275 grs. of soda in 1000 grs. porter.

The following are the amounts of the various constituents in 1000 parts by measure of the Porter:—

	I.	II.	Mean.
Total Amount of fixed Organic Matter, .	67·566	66·426	66·996
Total Amount of fixed Inorganic Matter,	4·166	4·270	4·218
	71·732	70·696	71·214
Proof Spirit,*	89·6	92·0	90·8
Acetic Acid, ...	3·6	3·6	3·6
Grape Sugar, ...	1·72	1·72	1·72
Albumen, ...	8·272	7·50	7·886
Extractive Matter, ...	57·574	57·206	57·390
Silica, ...	·290	·290	·290
Phosphoric Acid, ·544 Magnesia, . . . ·307 —— ·851 } Phosphate of Magnesia, .	·851	·851	·851
Lime, ...	·085	·085	·085
Phosphoric Acid, ...	·690	·703	·697
Chloride of Sodium, ...	·448	·449	·448
Sulphuric Acid, ...	·277	·274	·276
Potash, ...	1·527	1·500	1·513
Soda, ...	·082	·083	.082
	71·816	70·661	71.238

In One Gallon by Measure,

Total amount of fixed organic matter, ...	4689.70
Total amount of fixed inorganic matter, . .	297.64
	4987.34
Alcohol (proof spirit), ...	6356.00
Acetic acid, ...	252.00
Sugar, ...	120.50
Albumen, ...	552.00
Extractive matter, ...	4017.30
Silica,.	20.30
Phosphate of magnesia, ...	59.71
Phosphate of lime, ...	11.06
Phosphoric acid, ...	44.31
Sulphate of potash, ...	42.00
Potash, ...	83.16
Chloride of sodium, ...	31.36
Soda, ...	5.74
	4987.44

---

* Proof spirit has a sp. gr. of 0·9198 at 60° Fahr. and contains 49¼ per cent. by weight of real alcohol.

In stating the proportion of the inorganic constituents, we have combined in the gallon the magnesia and lime with phosphoric acid, the chlorine with sodium, and the sulphuric acid with potash; leaving part of the potash, part of the soda, and part of the phosphoric acid, uncombined. Our reason for this was, that when we combined them together, we found an excess of the bases over what was requisite to form with the phosphoric acid salts having the formula of $2MO, PO_5$; and an excess of phosphoric acid, if we gave the salts the formula of $3MO, PO_5$.

Without expressing any opinion as to the medicinal virtues of the porter we examined, we may, perhaps, be permitted to draw attention to the facts which our analysis reveals, that it contains a large quantity of heat and flesh-producing matter, as well as the necessary inorganic constituents required in the formation of bone and flesh.

As we were obliged to limit ourselves to one sample of porter, as it would have required more time than we could give to have examined samples of porter from all the different manufactories, we selected Guinness's as the type of all the rest.

XX.—On the Generative System of Helix Aspersa and Hortensis.

By Henry Lawson, M.D.

(Plate VIII.)

[Read before the Natural History Society of Dublin, Friday, December 7, 1860.]

The following observations upon the reproductive system of *Helix aspersa*, our commonest Irish snail, are given as the result of a series of dissections and microscopic examinations, made during the past summer. The object of the paper is twofold—firstly, to supply a deficiency in our text-books on zoology and comparative physiology, by publishing the descriptive anatomy of the species of *Helix* most widely distributed in Ireland, and of thus affording to the student of natural history an opportunity of verifying by dissection the descriptions given—a circumstance too much neglected by writers upon the subject, who prefer the less difficult task of quoting, wholesale, the investigations of Cuvier, which were made upon that species (*Helix pomatia*) most abundant in his own neighbourhood. Secondly, to put forward my own opinion concerning the relations of function of the parts which compose this system.

The generative organs of this animal are hermaphrodite in their nature, and excessively complicated in their arrangement. They occupy a larger volume of the body comparatively with the other systems than at first one would be inclined to suppose, extending from one extremity to the other, and seeming more or less closely related to every organ in the economy of the creature. They present an external aperture adjacent to the right upper tentacle, and terminate at the ovary, in the final spire of the shell. For convenience, they may be divided into four groups:—

1. Female.
2. Male.
3. Androgynous.
4. Appendicular.

Of these, the female organs form by far the largest portion, and extend over the greatest surface. They consist of an ovary, oviduct, albumen-gland, and uterus. The ovary is a small, rather compact, fan-shaped gland, spread over the last lobe of the liver, and, with it, included in the terminal volution of the shell; its broad, or basal extremity, is most external, the narrow portion being directed inwards, to terminate in the commencement of the oviduct. When separated from its attachments, it measures at its widest part about three-eighths of an inch; whilst from within outwards, it is about a quarter of an inch. It is composed of numerous branching cœca, or lobules, of a light-yellowish colour, bound together by folds of a delicate areolar, or fibrous membrane. A portion placed under the microscope presents the appearance of a follicle, secreting from its inner wall numerous oval, or spherical, nucleated cells, and having occasionally within it, and rather near its mouth, a few isolated zoosperms—no trace whatever of a second sac invaginated by the former can be observed. The ducts of the various lobules unite toward the apex of the organ, and form a common channel—the oviduct. This vessel bends its course in a spiral direction, from the ovary to the albumen-gland. It is simple at both extremities, but very much convoluted in the interval. It is about seven-eighths of an inch in length; and before it terminates in the sinus of the albumen-gland, it makes a slight spur-like turn backwards. (I have not seen any of those decided projections on its convoluted portion, which Professor Goodsir has described as existing in *Lymneus involutus.*) Examined microscopically, nothing resembling a second tube included within the duct is to be seen. The albumen-gland is a large, homogeneous-looking structure, in shape like a boat, situated in the first spire of the shell, of which it occupies one-half. It lies beneath the lung, rectum, heart, and urine-gland. Its concave surface embraces the second spire, whilst its keel is bounded externally by the liver, into which its apex or prow also projects, its base or stern being attached to the upper extremity of the uterus. It measures about an inch in length, and is composed apparently of two distinct portions, an opaque and a translucent. It is very difficult, if not impossible, to ascertain its minute structure. A central duct traverses its substance, which would seem to collect from others more minute the peculiar gelatinous secretion. Viewed under the microscope, a confused chaos of spherical albumen-globules and minute fibres is observed. I have not found any zoosperms in this organ. The sinus is a membranous expansion, formed at the point of junction of this gland with the uterus; into it the oviduct passes, after having been lodged for some short distance in the substance of the albumen-gland. The uterus is a sacculated duct, measuring usually an inch and a half in length, and being fully one-eighth of an inch in calibre. Starting from the last-named gland, it makes two or three zig-zag turns, and ends as a cylindrical vessel in the vagina. It is closely adherent along its whole length, to the testis which lies on its left border, and which, being shorter than the uterus itself would be if isolated, has the effect of producing the various sacculi above described; so that the two together have not been inaptly compared to the intestine supported by its mesentery. It is situated upon the powerful muscles of the foot, and has the gullet and salivary-glands on its left. At the period of depositing the eggs, this vessel becomes enormously distended, the sacs appearing much more distinct than usual, each containing its large ovum, and separated from its neighbour by a well-marked constriction. I am inclined to agree with Turpin, in believing that the uterus secretes those beautiful rhombic crystals of carbonate of lime seen on the egg of this animal, inasmuch as I have not found them upon those ova which had just entered the upper sacculi, whilst those situate in the lower ones were invariably studded with them.

The male organs lie to the left of the female, and include the testis, vas deferens, and penis, with its flagellum. The first, as before mentioned, is closely united to the uterus, commencing and terminating with it; nevertheless, it is a very distinct and extensive structure, and deserves far more attention than has been heretofore bestowed upon it. It consists of a central duct, closed at its posterior extremity (as shown by the obstruction to liquids introduced as injections), which is beset on its sides by two rows of long white granular-looking follicles. These are observed, under the microscope, to open into the central channel, and to contain those oval and elliptical epithelial-like cells, usually described as the parents of zoosperms. The central vessel now leaves the testis, at the point of union of the uterus and vagina, and is continued as a simple duct for a distance of an inch and a half, or thereabouts, when it terminates by a rounded aperture in the penis. It is this portion to which the term vas deferens has been applied. The penis is represented by a long attenuated tube, wide, and of rather thickish consistence at its base, which is perforated, and communicates with the generative outlet, cœcal at its apex, which is extremely delicate, and situate deeply in the mass of viscera. It communicates with the vas deferens by a small aperture, distant from the basal opening about an inch and three-eighths, and measures, from end to end, when extended, about three inches and a quarter. The blind extremity, from its fancied resemblance to a whip-lash, has been termed the flagelliform portion. About the junction with the vas deferens, there exists, attached to the penis, a strong muscular fasciculus, which probably performs the function of drawing back this organ after it has been everted in copulation.

The androgynous group includes the vagina, vas deferens, and sperm-sac, with its duct and cœcum.

The vagina is usually described as the termination of the uterine portion; but from the direct continuation which it forms with the copulative vessels, and its almost rectangular connexion with the uterus, it seems more correct to look upon it as the dilated extremity of the former. Viewing it thus, both may be said to constitute a tube, leading from the dart-sac, on the one hand, to the sperm-sac, on the other, wider at its proximal than at its distal end, about one inch and three-eighths in length, and one-sixteenth of an inch in diameter, following a backward course, beneath the superficial viscera, toward the anterior margin of the liver, where it expands abruptly into a spherical or pyriform bag—the spermatheca, or sperm-sac. This vesicle, whose office appears to be the storing up of the semen received during coition, varies in its dimensions under different conditions. Thus, immediately after union of the sexes, when distended by its seminal contents, I have often found it attain the size of a large swan-drop, being more than a quarter of an inch in diameter; whilst in specimens examined some time after the performance of the sexual function, it has rarely exceeded the bulk of a grain of sparrow-shot. I have had many opportunities of observing the nature of the contained zoosperms, yet I have never succeeded in seeing them isolated—they were invariably in enclosed bundles, or spermatophora. The cœcum is an appendage whose function, so far as I am aware, has not yet been investigated. It is a duct, springing from the copulative tube, at about a quarter of an inch from its union with the uterus. It measures three inches in length, is of slightly greater calibre than the tube, and terminates, by a blind extremity, at the point of junction of the uterus and albumen-gland. It is closely attached to the sinus before described, and, to a superficial observer, would seem to convey thus the male element to the female. It seems homologous with the duct connecting the sperm-sac and ovary in *doris* and *eolis*, which Messrs. Alder and Handcock have described in their anatomy of the Nudibranchs.

The appendicular group comprises the dart-sac, dart, and multifid vesicles. The dart-sac is a pyriform vesicle, bearing in miniature a decided resemblance to the human uterus; it is situated at the anterior extremity of the animal, to the right of the testes and penis, and is quite superficial, being covered only by the outer integument and loose fibrous tissue which involve the other organs. It is about half an inch in length, and in diameter a little above a quarter at its bore or fundus, and is provided with very dense and apparently muscular walls, which are pierced on the left, close to the external opening, by the termination of the vagina; it communicates with the generative cloaca by a small circular outlet, which is guarded by two delicately constructed lips. These may be traced from their point of union on the right side of the orifice, passing round and approximating on the left, where they leave a small portion unprotected. I would be cautious in hazarding an opinion upon their function, but it seems to me not unlikely that they may direct the penis in entering the vagina, and so prevent the possibility of its being lacerated by any existing remnant of the dart; while, on the other hand, by opening in a valve-like manner externally, they thus offer no obstruction to the exsertion of the latter. Springing from the fundus of the sac is observed a fleshy conical projection, armed at its free end with a calcareous spicule—the dart or stilette. This projection, or papilla, is about one-eighth of an inch in length, and is distinctly tubular, being connected at the base with a small follicle, situated between the layers of the dart-sac. The stilette appears to be the secretion of this papilla; it is perfectly transparent, about a quarter of an inch long, tapering from base to apex, it is tetrahedral in form, the sides being trenchant; a transverse section appears like a square, upon each of whose external sides an equilateral triangle had been constructed; it is perforated throughout, and at its papillary extremity is funnel-shaped, the lips also being slightly everted, or trumpet-like. Thus it would seem to have the power of conveying the product of secretion of the follicle (if any) through the dart, and in this way by inoculation of inflicting the "love-inspiring wound." I believe it has been asserted on all hands that the stilette never penetrates beyond the integument of the animal against which it is projected; that such an assertion is correct I must with all deference deny, as I have in several instances observed it lying deeply imbedded among the viscera, whilst a second, quite distinct, existed in its normal position within the sac; nay more, from one specimen, which I examined at the period of depositing the eggs, I succeeded in extracting two almost perfect darts.

The multifid vesicles are a number of branching cœca, produced by the dichotomous division and subdivision of two small ducts, whose orifices are situate upon each side of the vagina, adjacent to its union with the dart-sac. In all there are about forty cœca, and each group extends for about half an inch in the lateral direction. As yet no distinct function has been assigned to them.

The cloaca is the canal which leads from without to the two great orifices of the genital organs within; it is of all, the most anterior; it is a very flexible vessel, about a quarter of an inch in length, and one-eighth in calibre; it terminates externally in a vertical slit, closed during life by a sphincter of elastic membrane. This, which is sometimes termed the generative outlet, lies at the distance of a quarter of an inch from the upper tentacle, on the right side, in a plane posterior, and a little inferior. Near this outlet is the communication with the penis, whilst at the further extreme of the cloaca is observed the orifice of the dart-sac before-mentioned.

It will be seen by the foregoing remarks that I have taken a view of the parts composing the generative system different from that heretofore put forward on the matter. The older supposition was, that the liver-imbedded gland represented the ovary, whilst the tongue or boat-shaped structure performed the part of testes;* more recently it has been conceived by Henrich Meckel, Siebold, Gegenbaur, and Moquin-Tandon, that the so-called ovary of the older writers is in reality an hermaphrodite gland, each lobule of which has contained within it a second, the external secreting ova, the internal zoospores, the oviduct also having a second vessel invaginated by it. Of these four, however, the two latter, who have been the latest to write upon the subject, deny that any included sac or duct exists. Moquin-Tandon, moreover, follows Van Beneden in his ideas concerning the prostate.

---

* This was Cuvier's idea, and also that of J. F. Meckel, Carus, Erdl, Sister, Bendach, Pappenheim, Berthelen, Fyfe, and Rymer Jones. Van Beneden also held it; but he considered that gland a prostate, which is here maintained, to be in the sperm-secreting organ.

The following are some of the reasons which urged the adoption of the view I have now put forward.

Concerning the Ovary :—

A. Arguing merely from authorities, I feel inclined to agree with Cuvier and his disciples, inasmuch as his opponents, though men of great research and vast fame, are but few in number, and are equally divided in a matter of observation, upon which, in fact, their argument is wholly based.

B. I have carefully from time to time examined single lobules under the microscope with the aid of the compressor, and never have I succeeded in bringing any contained sacculi into view; although, when I placed several lobules in the compressor, I had an appearance produced somewhat resembling invagination, but evidently the result of some lobule becoming superimposed, and then pressed into the substance of another.

C. There being no invaginated duct leading from the ovary, the zoosperms, if there secreted, would have a greater tendency to pass into the normally widened uterus than into the constricted vas deferens (indeed, the latter passage could not be effected, as there is no communication of the vas deferens with the uterus), and so would pass away externally, and be lost; but such a state of things could not reasonably exist.

D. From my own observations I may make use of Mr. Handcock's most ingenious argument applied to the Nudibranchs, that, as the zoosperms were found in a condition of imperfect development in the sperm-sac, and fully matured and isolated in the lobules of the ovary, they could not have proceeded from the latter; for, had they been there secreted, they would have been observed in process of development in the ovary, and fully formed and unconnected in the spermatheca.

Respecting the Testis.

A. As there is but one gland in connexion with the vas deferens, and that so extensive as to rival the ovary in size and structure, we may fairly conclude that, if a testis exists at all, it is most probably its representative. It seems to me very unreasonable to term this gland, as Van Beneden has done, a *prostate;* such a mode of applying names to parts is more to be deprecated than the barbarous terminology of human anatomists, who not unfrequently call an interesting and peculiar structure *innominata*, when, to quote the language of a well-known author, "their little puddle of invention has been used dry." I cannot conceive what resemblance it is supposed to bear to an appendage found in another sub-kingdom, and whose function is so much unknown, that of two of the most distinguished physiologists of the day, one thinks it little more than a mass of muscles,—the other that, most probably, it is the part in the male homologous with, or representing, the uterus of the female.

B. The generative organs of the nudibranchiata, which have been so *exquisitely delineated* by Messrs. Alder and Handcock, bear on the whole so great an analogy to those of the pulmonifera, that it is very likely, as the sperm and germ producing organs are isolated in the former, so are they in the latter. The vas deferens in helix, with its continuation, the testis, which is attached to the border of the uterus, holds the place of the greatly elongate corresponding vessel in eolis, here being, however, less distinction or separation of parts.

EXPLANATION OF PLATE VIII.

A. The entire reproductive apparatus, natural size—*a*, albumen gland; *c*, cœcum; *d*, dart-sac; *o*, ovary; *ov*, oviduct; *p*, penis; *ou*, outlet; *v*, vagina; *vm*, multifid vesicles; *s*, sperm-sac; *sd*, spermatheca-duct; *t*, testis; *u*, uterus; *vd*, vas deferens.

B. Vertical section through the dart-sac, enlarged, representing the follicle, papilla, dart, protective valve, and orifice of vagina.

C. Outline view of the testis, greatly magnified.

D. A lobule of the ovary, enormously enlarged, exhibiting the absence of included lobule, and the isolated zoosperms at the aperture.

E. Transverse section through the stilette, exhibiting the trenchant outline and central perforation.

BIBLIOGRAPHY.

Berthelen.—Ann. des Sci. Nat.
Burdach.—Quelques considérations sur le nidamentum.
Carus.—Beiträge zur genauern kenntniss der geschlichts-organe und functionen einiger Gasteropoden. Müll. Arch., 1835.
Cuvier.—Le Regne Animal. Tome v. Mollusques.
Erdl.—Beiträge zur Anatomie der Heliceen. Müll. Arch.
Fyfe.—Outlines of Comparative Anatomy. 1831.
Gegenbaur.—Vergleichenden anatomie. 1859.
Jones, R.—Animal Kingdom, and Article Gasteropoda, Cyclopædia of Anatomy and Physiology.
Lister.—Exercitatio anatomica. London, 1684.
Meckel, H.—Müll. Arch., 1844, page 483.
——— J. F.—Ueber ein neues Geschlect der Gasteropoden.
Moquin-Tandon.—Histoire Naturelle des Mollusques terrestres et fluviatiles.
Pappenheim.—in Müll. Arch.
Siebold.—Wiegemans Arch., 1836, i., p. 51.
Van Beneden.—Memoire sur l'anatomie de l' Helix Algira. Brux. 1836.

XXI.—ON THE OCCURRENCE OF THE SNOWY OWL (*Nyctea nivea*) IN THE COUNTY MAYO. By ALFRED NEWTON, M. A., Fellow of Magdalene College, Cambridge, F. L. S., &c.

[Read before the Natural History Society of Dublin, January 4, 1861.]

As the snowy owl is stated by the late Mr. William Thompson, in his admirable work on the "Birds of Ireland" (i. p. 95), to be "a very rare winter visitant" in that country, a record of the capture of one which I lately had the pleasure of seeing, may not be unacceptable to the Members of the Dublin Natural History Society. The bird I speak of was obtained at Ballycovey, in the County Mayo, on the estate of Mr. George Clive, Under-Secretary of State for the Home Department, and, as far as I could ascertain, somewhat late in the autumn of 1859. When first observed, it was sitting on a bog, and was approached without difficulty. The man who found it had no idea what it might be, and shot at it, wounding it slightly, but sufficiently to enable him to catch it alive. It soon recovered from the injury, and lived contentedly in a roomy cage until the beginning of October last, when, at my suggestion, Mr. Clive presented it to the Zoological Society of London, in whose gardens I saw it a week or two since, enjoying the society of a fellow-prisoner of its own species, which was obtained in Unst, the northernmost of the British islands, and which has been for many years in the Society's possession. I was told by the man who looked after Mr. Clive's bird, that it moulted its feathers towards the end of the summer; and it certainly was in beautiful plumage when I saw it at Ballycovey, the last week in September. I may perhaps be permitted to add that, as far as my own knowledge extends, we are without any certain information respecting the change or changes of plumage in this species, and I believe that any person who could furnish reliable facts bearing on the subject would be doing good service to ornithology.

XXII.—ON THE OCCURRENCE OF THE SPOON-BILL IN THE COUNTY CORK. By R. P. WILLIAMS, M. R. I. A.

[Read before the Natural History Society of Dublin, February 1, 1861.]

IN presenting to the Society these fine specimens of *Platalea leucorodia*, or white spoonbill, I am aware that I cannot add anything new to the accounts already published in the several works on ornithology; but it may, however, interest the Society to enter into some details as to the particular birds in question. For two of the specimens we are indebted to my relative, Richard Quin, Esq., of Firgrove, Innishannon, County Cork. The village of Innishannon stands on the left bank of "the pleasant Bandon, crowned with many a wood," which rises from the river to a considerable elevation, facing the rocky hill clothed with wood, which, on the opposite side, rises nearly perpendicularly. Along both sides of the Bandon, there are alluvial flats, which above Innishannon form rich pasturage for cattle in the bends of the river; at one of which, opposite Firgrove, Mr. Quinn (1846) shot the fine specimen of the Canada goose (*Anser Canadensis*), which is in the museum of the Society; below Innishannon, whether it be from want of improvement, or from being at a lower elevation, these flats extend to a considerable length and breadth, nearly to Kinsale, where the river enters the sea. In very high tides and floods they are partially submerged; about three miles down the river from Innishannon lies Shippool marsh, adjoining Shippool Castle, a very old seat of the Herrick family.

Early in December last year, while looking for snipe on the marsh, Mr. James Herrick fell in with a flock of four spoonbills, of which he shot one; of this I had immediate notice from Mr. Quin, for I had previously requested him to be on the look out for rare birds, the river near Kinsale being celebrated for the number of water-fowl and waders that frequent it. I wrote to him to endeavour to secure it, if it was really a spoonbill, and not the shoveller duck (*Anas clypeata*), which is often so-called; the result was, that Mr. Herrick most kindly presented it at once. For some days after, two were seen, and Mr. Quin was indefatigable in trying to secure them for me; but, owing to their wildness, it was very difficult to approach them. He, however, succeeded in shooting one (the specimen which I have had set up with expanded wings, to show the peculiar black shafts); the other he wounded; but on account of the extent of slob uncovered by the receding tide, it escaped, and has not since been heard of; it probably died, and was carried away by the winter's floods, which in the Bandon are very powerful on the fall of the tide, which rises to a considerable height, and pushes its waters as far as Innishannon Bridge.

About the same time, another was shot by Thomas Hungerford, Esq., of the Island, Clonakilty, County Cork, which he has also presented. These three birds were immature males, and, I presume, birds of the second year; what impresses me with this idea is, that I learn three other specimens have been sent to Mr. Glennon, of Suffolk-street, to be preserved, all of which were males; they were smaller, and not so white as the specimens before you; they are probably of the same age as the living specimens which may be seen at the Zoological Gardens.

On consulting Mr. Yarrell's work, and others relating to the spoonbills, it will be found that considerable differences are apparent between the immature and adult bird, the most remarkable of which is the crest or mane of elongated feathers of the occiput and neck in the adult birds. In the present specimens, there is but a very partial elongation; the colour of these is altogether white, except the shafts of the wing feathers; but in the adult a band of buff feathers covers the breast, extending upwards. The colour of the eye of the young birds is ashey-grey; in the adult it is orange-red; and probably the same takes place in the eyes of other birds that, when mature, are of a bright red or yellow, as in the case of the Egyptian goose, &c. We are told, also, there is a cere round the eyes to the base of the beak, which, in the immature birds, is covered with feathers.

Fortunately for information, these birds all fell into the hands of inquiring observers, by whom it was thought advisable to examine the contents of the stomachs, so as to find out on what these birds subsisted during a season the most inclement we have had for several years, in spite of which the birds were in fine condition. In the works that I have been able to consult, the food is set down as small crustacea, molluscs, spawn of fishes, &c., but in none, except Morris, who says, "in addition, they eat grasses and the roots of plants," do I find any mention of what *all* these birds' stomachs contained, vegetable matter, probably some of the marsh grasses; no traces of crustacea or animal matter were found. Now, looking to the conformation of its beak, armed with a sharp broad nail at the end, I do not see why vegetable substances should not form a portion of their food, as in the case of the duck tribe, the palate and sides of whose beaks are not very dissimilar; and therein perhaps we may find a provision of nature by which the bird, in the absence of more favourite food, may adapt itself to altered circumstances; the breast-bones of these birds are produced before you; but I regret I am unable to exhibit the trachea, which are very remarkable, but, owing to some misunderstanding, they were not preserved. The fine plate in Yarrell's "British Birds," showing the peculiar figure of 8 contortion, will, however, supply the deficiency, and enable the Members to observe its peculiarity.

In the work of the late Mr. Thompson, we find records up to 1846 of those shot in Ireland; but I suspect others, as well as of many birds considered extremely rare, but not so, are, from the non-observant habits of our country gentlemen, altogether overlooked. I have heard that Dr. Harvey, of Cork, is aware of one shot in that county in 1859, and another at Westport; another was shot at the mouth of the Boyne, about the year 1854, by Reynolds, warrener to James Brabazon, Esq., of Mornington, but unfortunately not preserved, although lying for some time in the kitchen, and finally thrown out.

It would seem remarkable, that in the accounts published of the several captures, all the instances are on the sea-board, none in the inland counties, although extensive lakes and marshes abound, the resort of birds feeding similarly. The records of Thompson show that in 1808 one was shot in the Co. Antrim; two in Donegal in 1837 and 1838; one in the County Dublin, near Malahide (the specimen in the Society's collection), in November, 1841; one in the Co. Wicklow, in October, 1844; three in the Co. Wexford, in 1836, November, 1844, and in July, 1840; three in the Co. Waterford, in 1829, 1843, and 1845; two in the Co. Kerry, in 1832 and 1846: to the foregoing list, those shot in the Co. Cork are now added. The question why this should be I leave to those naturalists who have devoted their attention to the migration of birds. Were these birds on their southward flight to more genial climes? How is it to be accounted for that all were males? We learn that the spoonbills' nests only contain four eggs. Can the four alluded to have been all of the same nest—and the three others, sent to Mr. Glennon, have been also from one nest, as they appeared to be nearly identical in plumage? Or, do the sexes separate in the winter time, again to re-unite when the pairing season arrives?

I learn that when these birds were shot, the weather was mild; but previously there had been north-easterly gales, and they might have been returning from their breeding places in the North of Europe.

Some years ago, I had three of these birds alive, which were at first kept in a small enclosure, and subsequently enlarged on the ponds at Drumcondra Castle, which were wired around; they throve very well, wading along the edges, feeding on various substances, and with the waterfowl on a mixture of bran, potatoes, and oats; I do not recollect that anything else was supplied to them: after some time they escaped, but how I cannot tell; one thing I particularly remember, that it was very unpleasant to handle them, from the very disagreeable odour attached to them; and that they were covered with parasites, which ran about on the hands, if the birds were laid hold of. I shall now conclude by urging on the Members to exert themselves among their friends in the country, by which means many rare objects of natural history may be secured, and thus complete our museum of natural history.

XXIII.—TABLES AND DIAGRAMS RELATIVE TO THE RAIN-FALL AS OBSERVED IN THE MAGNETIC OBSERVATORY OF TRINITY COLLEGE. By the REV. JOSEPH A. GALBRAITH. (Plates IX., X.)

[Read before the Royal Irish Academy, Monday, February 25, 1861.]

Table I. gives the annual and monthly rain-falls for the last ten years, 1851–1860.

Table II. gives the monthly rain-falls of the ten years (1841–1850) as compared with those of the last ten years (1851–1860).

The numbers for the first ten years are taken from Dr. Lloyd's account of the Meteorology of Ireland, vol. xxii. of the Transactions of the Academy.

From this Table it appears that the mean rain-fall at Dublin for twenty years (1841–1860) = 29·02 inches.

Table III. gives the distribution of the rain-fall, according to the seasons, for ten years (1851–1860), from which the following mean values are obtained:—

Spring (March, April, May), ...	6·33
Summer (June, July, August), ...	7·81
Autumn (September, October, November), .	7·73
Winter (December, January, February), . .	6·76

In computing these mean values, the rain-falls for January and February, 1861, as taken from the day-book of the Observatory, were used as follows:—

January, ...	2·18
February, ...	3·67

It may be observed that the month of February, 1861, has been the wettest February for the last twenty-one years, the rain-fall being more than double the average amount.

Table IV. gives the number of dry days in each month for the last ten years (1851–1860). In this Table a day is counted dry if the rain-fall is less than a hundredth of an inch.

Average number of dry days in the year = 191·6
Average number of wet days in the year = 173·4

During the last ten years there have been only twenty-three days on which the rain-fall has exceeded one inch, and only thirty-three days on which it has exceeded seven-tenths of an inch. The heaviest rain-fall, amounting to 1·78 inch, occurred on the 1st of April, 1853. The two wettest consecutive days were 27th and 28th of September, 1856, on which 2·72 inches of rain fell; 1·31 inches on the 27th; and 1·41 inches on the 28th.

Plate IX. represents the rain-fall for twenty years, from 1841–1860; the ordinates which represent the depths of rain are drawn to a scale of one-tenth.

Plate X. represents Kirwan's observations on the rain-fall in Dublin, as observed at his house in Cavendish-row, from 1792–1808. These observations are to be found in volumes v., vi., vii., viii., and x. of the Transactions of the Academy. There seems to be no record of the year 1793.

The rain-gauge of the Magnetic Observatory is circular, having an orifice of 12 inches, and is placed on the flat roof of the Observatory, which is 17 feet above the level of the ground.

Table I.

Rain-fall for ten years, 1851–1860.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1851	5·28	0·49	2·38	1·77	1·31	2·71	3·48	2·01	1·81	3·27	1·01	0·88	26·40
1852	3·20	2·72	0·61	1·28	2·35	7·09	1·96	3·27	2·69	3·46	7·43	4·10	40·16
1853	2·75	2·16	1·63	3·81	1·04	1·91	2·73	1·93	2·39	4·32	1·69	2·60	28·96
1854	3·83	0·75	0·67	0·40	2·43	3·93	2·29	1·24	0·91	1·64	3·15	2·60	23·84
1855	1·24	2·83	1·50	0·59	1·74	1·92	3·68	2·74	1·34	4·83	1·41	1·65	25·47
1856	2·64	1·93	0·77	1·58	5·49	2·40	1·41	2·60	3·88	2·03	0·65	2·55	27·93
1857	2·66	1·30	3·13	3·96	1·48	3·28	1·65	1·20	1·57	2·65	1·79	0·44	25·11
1858	1·04	1·03	1·14	5·08	1·64	1·37	3·34	1·66	3·02	3·31	1·38	3·06	27·07
1859	1·43	1·00	2·59	3·99	0·68	1·24	1·35	1·92	3·01	1·62	3·24	3·21	25·28
1860	4·15	0·84	2·57	2·62	3·12	4·59	2·43	4·75	2·65	2·27	2·90	3·17	36·06
Mean	2·82	1·50	1·70	2·51	2·13	3·04	2·43	2·33	2·33	2·94	2·46	2·43	28·63

Table II.

Monthly rain-falls from 1841–1850, *compared with those from* 1851–1860.

Mean Value.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1841–1850	2·64	1·86	1·90	2·58	2·11	2·16	2·34	2·74	2·33	3·35	3·03	2·38	29·42
1851–1860	2·82	1·50	1·70	2·51	2·13	3·04	2·43	2·33	2·33	2·94	2·46	2·43	28·62
1841–1860	2·73	1·68	1·80	2·54	2·12	2·60	2·39	2·54	2·32	3·15	2·75	2·40	29·02

Mean rain-fall for twenty years (1841–1860) = 29·02 inches.

TABLE III.

Distribution of rain-fall according to the seasons.

Years.	Spring.	Summer.	Autumn.	Winter.
1851	5·46	8·19	6·09	6·80
1852	4·24	12·32	13·58	9·01
1853	6·48	6·57	8·40	7·18
1854	3·50	7·47	5·70	6·67
1855	3·83	8·34	7·58	6·22
1856	7·84	6·41	6·56	6·51
1857	8·57	6·13	6·01	2·51
1858	7·86	6·37	7·71	5·49
1859	7·26	4·51	7·87	8·20
1860	8·31	11·76	7·82	9·02
Mean,	6·33	7·81	7·73	6·76

TABLE IV.

Number of dry days in each month, with their average for ten years.

[N. B.—A day is counted dry if the rain-fall is less than the hundredth of an inch.]

Years.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Dry days.	Wet days.
1851	8	19	10	17	18	16	16	9	24	16	17	21	191	174
1852	13	13	26	25	18	8	21	14	16	15	11	8	188	177
1853	12	12	15	23	20	17	13	23	19	11	15	14	184	181
1854	7	11	33	23	16	15	16	16	21	14	11	11	184	181
1855	16	9	18	22	16	14	16	14	20	13	21	16	195	170
1856	7	13	25	16	15	15	17	16	11	20	25	18	198	167
1857	14	16	14	7	22	19	15	19	15	16	21	20	198	167
1858	21	20	20	14	17	21	16	20	16	16	21	11	213	152
1859	20	13	13	14	26	22	21	16	11	17	13	18	204	161
1860	7	18	9	16	12	8	20	9	18	14	16	14	161	204
Aver. no. of dry days.	12·5	14·4	17·3	16·7	18·0	15·5	17·1	15·6	17·1	15·2	17·1	15·1	191·6	
Aver. no. of wet days.	18·5	13·6	13·7	13·3	13·0	14·5	13·9	15·4	12·9	15·8	12·9	15·9		173·4

XXIV.—On Clairaut's Theorem. By Professor Hennessy, F. R. S.

[Read before the Royal Irish Academy, February 25, 1861.]

Laplace has shown that this theorem follows whatever may be the density of the interior parts of the earth, provided it consists of similar concentric strata, and that the form of the outer stratum is ellipsoidal. In the "Philosophical Transactions" for 1826, Mr. Airy (the present Astronomer Royal of England) has presented an equivalent result; more recently, Professor Stokes has shown that we can deduce the law of variation of terrestrial gravity without any hypothesis whatsoever as to the earth's interior structure. He assumes merely that its surface is spheroidal, and that the equation of fluid equilibrium holds good at that surface. In vol. vi. of the "Cambridge Mathematical Journal," Professor Haughton presented a demonstration, founded upon the same assumptions as those of Professor Stokes, and in which he uses certain propositions relative to attractions which had been enunciated by Gauss and Mac Cullagh. While studying thela bours of those mathematicians, it appeared to me that the question could be entirely divested of the hydrostatical character, and that Clairaut's theorem may be directly deduced from the equations to the normal of any closed surface, without any considerations as to the physical condition of the matter forming that surface. Thus every surface concentric with the earth, and perpendicular to gravity, will possess the property of exhibiting this relation in the intensity of gravity at its various points.

Let X, Y, Z represent the components parallel to the rectangular axes of the forces by which a point is retained at rest on a given surface whose equation is $L = 0$. Then from the equations of the normal we have

$$Y\frac{dL}{dx} - X\frac{dL}{dy} = 0, \quad Z\frac{dL}{dx} - X\frac{dL}{dz} = 0,$$

when the resultant of these forces is perpendicular to the given surface. If we represent by V the potential of the earth on the particle in question, by w the angular velocity of rotation, we have

$$X = \frac{dV}{dx} + w^2 x, \quad Y = \frac{dV}{dy} + w^2 y, \quad Z = \frac{dV}{dx},$$

and the above equations become

$$\frac{dV}{dy}\frac{dL}{dx} - \frac{dV}{dx}\frac{dL}{dy} = w^2\left(x\frac{dL}{dy} - y\frac{dL}{dx}\right)$$

$$\frac{dV}{dz}\frac{dL}{dx} - \frac{dV}{dx}\frac{dL}{dz} = w^2\, x\,\frac{dL}{dz}.$$

If, in conformity with General Schubert's* recent determinations, we assume the earth's surface to be that of an ellipsoid, with three unequal axes, we should substitute for L

---

* Mémoires de l'Académie Imperiale des Sciences de St. Petersbourge, VII^{e} serie, tome i.

$$\frac{x^2}{a^2} + b^2 + \frac{z^2}{c^2} - 1 = 0,$$

or

$$\frac{dL}{dx} = \frac{2x}{a^2}, \quad \frac{dL}{dy} = \frac{2y}{b^2}, \quad \frac{dL}{dz} = \frac{2z}{c^2};$$

whence we have

$$b^2x\frac{dV}{dy} - a^2y\frac{dV}{dx} = w^2xy\,(a^2 - b^2), \quad c^2x\frac{dV}{dz} - a^2z\frac{dV}{dx} = w^2a^2xz.$$

Each of these partial differential equations can be easily integrated, and the value of V, finally obtained, is equivalent to the equation of fluid equilibrium; or

$$V + \frac{w^2}{2}(x^2 + y^2) = C.$$

Let θ represent the complement of the latitude, and ϕ the longitude, counted from the meridian of the greatest axis, then $z = r\cos\theta$, $x = r\sin\theta\cos\phi$, $y = r\sin\theta\sin\phi$, and

$$V + \frac{r^2w^2}{2}\sin^2\theta = C.$$

In the case of an ellipsoid having the ellipticity e, we have, neglecting small terms,

$$r = a\,(1 - e\cos^2\theta).$$

From these equations, and from the properties of Laplace's functions into which V can be expanded, an expression can be obtained of the same kind as that deduced by Professor Stokes from his own and Gauss' theorems relative to attractions.

XXV.—On the Storm of the 9th of February, 1861. By the Rev. Samuel Haughton, F. R. S., Fellow of Trinity College, Dublin.

(Plate XI.)

[Read before the Royal Irish Academy, on Monday, February 25, 1861.]

On the 11th instant I expressed to the Academy my opinion, that the disastrous storm of the 9th instant was not a Cyclone, and that its occurrence could not therefore be predicted from barometrical observations made in a single locality. Further inquiry into the circumstances of this storm shows that this opinion was correct, and that it constitutes an admirable example of Dove's second kind of storm, outside the limits of the Trade winds (Ueber das Gesetz der Stürme, p. 48.) In this class of storms, there is a direct opposition between the S. W., or equatorial current, and the N. E., or Polar current, of air; there is generally a succession of non-cyclonic gales, N. E. and S. W.; and when the S. W. wind gives place to the N. E., there is a rising barometer and minimum temperature corresponding to the time of the storm. The following facts place the peculiar and non-cyclonic character of this storm beyond all doubt.

Dublin.—In this city a wave of atmospheric pressure occurred, of 8 days, 4 hours' duration, the two crests of the wave being—

1st crest, Feb. 1^{d} 22^{h}; Barom. = 30·70 in.
2nd crest, Feb., 10^{d} 2^{h}; Barom. = 30·48 in.

And the hollow of the wave being—

Feb. 5^{d} 2^{h}; Barom. = 29·00 in.

The gale or storm occurred of maximum violence,—

Feb. 9^{d} 22^{h}, velocity 24 miles per hour.

The accompanying Table shows all the circumstances of the week preceding the storm:—

MAGNETICAL OBSERVATORY, TRINITY COLLEGE, 1861.

February.	Barometer, 1861.				Direction of Wind.			
	10 A. M.	1 P. M.	6 P. M.	10 P. M.	10 A. M.	1 P. M.	6 P. M.	10 P. M.
1, .	29·870	30·051	30·467	30·595	N. W.	N. W.	N. W.	W. N. W.
2, .	30·724	30·674	30·628	30·590	S. W.	S. W.	S. W.	S. W.
4, .	29·836	29·820	29·790	29·718	W. S. W.	W. S. W.	S. W.	S. S. W.
5, .	29·273	29·163	29·058	29·029	S.	S. S. W.	S. S. W.	S. S. W.
6, .	29·040	29·058	29·215	29·287	S. S. W.	S. W.	S. W.	S. W.
7, .	29·432	29·458	29·586	29·625	S. W.	W. S. W.	W.	W.
8, .	29·704	29·700	29·718	29·735	N.	N.	N. N. E.	N. N. E.
9,*.	29·982	30·048	30·228	30·316	N. N. E.	N. N. E.	N. E.	N. E.
11, .	30·180	30·087	29·990	29·929	N. E.	N. E.	E.	S. E.
12, .	29·707	29·670	29·610	29·585	N. E.	E. N. E.	S. E.	S. E.
13, .	29·738	29·781	29·879	29·932	S. E.	S. E.	S. E.	S. E.
14, .	29·880	29·745	29·669	29·602	S.	S. S. E.	S. S. E.	S. S. E.
15, .	29·425	29·363	29·333	29·377	S. S. E.	S. S. E.	S. S. E.	S. S. E.
16, .	29·563	29·531	29·533	29·541	S. W.	S. S. E.	S.	S.
18,†.	29·509	29·511	29·488	29·371	S. E.	S. E.	S. E.	S. E.
19, .	29·102	29·242	29·472	29·472	S.	S. W.	S.	S. S. E.
20, .	29·156	29·158	29·156	29·088	S. S. E.	S. S. W.	S.	S. S. E.
21,‡.	29·137	28·964	28·959	29·190	S.	S. E.	W.	S. S. W.
22, .	29·451	29·526	29·572	29·604	S. S. W.	S. S. W.		
23, .	29·740	29·758	29·896	29·982				
25, .	30·296	30·244						

---

* *Storm* at Dublin from N. N. E. Same point throughout. Velocity of wind, 24 miles per hour.

† *Gale* at Drogheda, Dublin, Dunmore East, and Penzance, from S. E. Same point throughout.

‡ *Storm* in London, Chichester, and Plymouth; gale in Dublin at midnight. At 7 P.M. in London the pressure was 36 lbs. per foot.

Wind in Dublin at same point throughout,—S. S. W.

From this Table it also appears that the equatorial wind (S. W.) continued from the 2nd of February, to the evening of the 7th of Feb., when it gave way to a West wind, then a North wind, and finally settled at 10, P. M., of the 8th, into a N. N. E. polar current, at which point it held throughout the storm, which reached its maximum twelve hours after the N. N. E. wind began to blow. On the night of the 9th of February it blew from the N. E., and so continued for 40 hours afterwards. The temperature, during the prevalence of the S. W. wind, and falling barometer, was mild, and the air damp, producing a feeling of closeness, from the vapour present in the air. For eight days previous to the minimum height of the barometer, the mean temperature was 49°·7; while during the three days following the minimum of the barometer, the mean temperatures were—

Feb. 7, at 10 A. M., . .	42°·5	
,, 8, ,, ,, . .	40 ·8	
,, 9, ,, ,, . .	35 ·1	maximum of gale.
Mean, . .	39°·4	

This shows a rising barometer, a falling thermometer, reaching a *maximum* and *minimum*, respectively, at the time of the storm; and on the 8th and 9th of February heavy hail showers fell at intervals. Such a phenomenon cannot by possibility be confounded with a Cyclone, which has a *minimum* barometer just before, and in the middle of the storm, and no such relation of the gale to temperature as Dove has pointed out in the class of storms to which that of the 9th of February unquestionably belongs. The storm of the 9th was also only the first of a series, arising from the same cause, viz., the direct and non-cyclonic collision of the equatorial and polar currents of air.

I have drawn in Plate XI. the curve of Barometric Pressure at 10 A. M. and 10 P. M. for the week preceding the 9th of February, and also the curve of Temperature at 10 A. M. during the same period. These curves show at a glance that the storm occurred on the maximum of pressure and minimum of temperature; that the rising barometer occurred with a wind shifting from S.W. by W. and N. to N. E., and that the curve of temperature is inverse to the curve of pressure. Combining these facts with the fact that the wind continued for twenty hours in the N. N. E., and for twenty hours more in the N. E., the storm occurring during the first of those periods, I believe it impossible to suppose that any Cyclonic movement could account for such a combination of circumstances. The succession of gales from the 9th to the 21st of February was due to the Equinoctial gales arriving this year before their time, as is indicated by the high temperature and great moisture of the month, and by the excessive rain-fall, occasioned by the conflict of the polar and equatorial currents, unusual at so early a period in the year.

A *second* gale occurred on the night of the 18th, which was felt severely at Drogheda, Dunmore East, and Penzance, and caused the loss of several vessels; at all three places the wind blew steadily from the S. E.

A *third* storm has been reported from London, Chichester, Plymouth, and other places, on the evening of the 21st of February. It was felt in Dublin early on the morning of the 22nd, from the S. S. W., but not severely. At 7 P. M., in London, it was at its height, and is said to have reached 36 lbs. per foot; and it had sufficient force to blow down the spire of Chichester Cathedral.

According to Dove's theory, these two storms are supplements to the storm of the 9th, and not distinct cyclonic movements.

Limerick.—I have ascertained from a respected correspondent in this city, that the barometer was rising slowly and steadily on the 3rd and 4th; during the night of the 4th it rose rapidly, and on the morning of the 5th it was over 30·5 inches. On the evening of the 5th, it began to fall, and continued to do so until the 9th, when the storm occurred at Dublin, at which time the barometer in Limerick stood at 29 inches. There was no storm felt in Limerick. It thus appears that the atmospheric curve in Dublin was the inverse of that in Limerick; and that on the mornings of the 5th and 9th there was a difference of pressure in these cities of above one inch, in opposite directions. Although the barometer in Dublin or Limerick alone would not have enabled an observer to predict a storm, yet any person acquainted with the condition of the barometer at both places might fairly have expected rough weather from the N. E., such as actually occurred on the morning of the 9th of February, in Dublin.

Mr. Haughton then read to the Academy the following letter from Mr. Robert H. Scott:—

"13, *Suffolk-street, February* 22, 1861.

"DEAR MR. HAUGHTON,—I see by your remarks at the last Meeting of the Royal Irish Academy, that it is your opinion that the storm of the 9th instant could not have been predicted from observations of the barometer here in Dublin. I think, therefore, that it may interest you to compare the behaviour of the barometer and thermometer in the British Islands during the past month with the records of their behaviour throughout Europe in seasons similar to the present. You are aware that Professor Dove, in his Law of Storms (Berlin, 1857), whom I quoted in a letter to 'Saunders' News-Letter,' on the 12th, classifies all storms under three heads.

"I. Cyclones.—Arising within the zone of the trades from the interference of the return with the normal current.

"II. Gales.—Arising outside these limits, from the meeting of the two currents (equatorial and polar) blowing in directions opposite to each other.

"III. Gales arising from the lateral interference of these currents when they are, as is frequently the case, flowing in directions opposite to each other in parallel channels.

"The first class is fully treated of by the late General W. Reid. Cyclones are always preceded by a fall of the barometer; and the direction of the wind changes according to fixed laws during their continuance.

"The second class cannot be predicted by insulated observations at any one point, but requires a large amount of data obtained from localities scattered over a wide area of country. They are indicated by the co-existence of a high barometer and low thermometer over the eastern portion of that area, while to the westward the instruments show great rarefaction of the air, and a mild temperature. In this case there is usually a succession of alternating N. E. and S.W. gales, separated by some days from each other. *There is no rotation of the wind* during these storms.

"The third class is rare. It arises from the fact that when the polar and equatorial currents are flowing in parallel channels, the latter will assume a more westerly direction than the former does easterly, owing to their friction against the earth's surface. There will, therefore, if the equatorial current lie to the southward, be a partial vacuum in it, and a liability to a N. W. storm, during which the barometer will rise; or, if the polar current lie to the south there will be a cyclone generated in it.

"If you will allow me to quote two cases from Dove's 'Mean Temperature for every five days' (Fünftägige Mittel, Berlin, 1856), I think that you will see that I may be justified in referring the storm in question to Dove's second class. I shall take the winters of 1850 and 1855.

"The cold in the north of Europe in January, 1850, was very intense, and reached a maximum about the 20th of the month This intensity was only felt at the stations situated at a low level, as the temperature at the Brocken, at an elevation of 3500 ft., was 28° F. above what it was at Heiligenstadt, twenty miles S. W. from that mountain. The barometer stood 9 lines above its mean level, along a line from Königsberg to Prague. On the same day there was a barometric minimum of 8·5 lines at North Salem in the state of New York. In this case we find the oscillations of the barometer, and the accompanying storms of wind and snow at Vienna. From the 19th, on which day there was a violent snow-storm, it rose 15 lines in two days, and the thermometer sunk to – 7°·6 F. On the 23rd the barometer fell again rapidly, and a N.N.W. storm, accompanied by a snow-fall of unusual magnitude ensued. In this case, we have at Vienna, lying on the line of contact of the two areas above referred to, a N.W. storm *preceded by a fall of the barometer.*

"On the other hand, E. storms, *accompanied by a rising* barometer, are recorded on two occasions in the winter of 1855–56.

"The autumn of 1855 was very warm and wet in the Mediterranean, while in the North of Germany it was marked by its extreme dryness, up to the end of October. In the middle of December the barometer rose to a great height over the whole of North Germany, the temperature sinking proportionably. From the 18th to the 21st a violent N. E. storm raged in the Black Sea, the Caledonia was lost at Sebastopol, and a fleet of ships were wrecked at the Sulina mouth of the Danube. Simultaneously with it there set in a violent S. E. storm in the British

Channel, and on the south coast of Ireland, while the lowest temperature at Greenwich was felt on the 22nd. Hence we see that the polar current had gradually forced its way to the west. This barometric maximum was succeeded by a minimum on the 8th of January, 1856, at which time a violent N. E. storm was felt over the greater part of the United States. In Europe a second maximum occurred on the 13th, and its advent was marked by a N. E. storm and sudden fall of temperature on the lower Danube. After this violent S. W. gales set in on the south coast of France and Spain, and the fall of the barometer was the precursor of a long spell of warm weather.

"In the case of the present winter we have had here in Ireland a low barometer and very mild weather, while in England the frost continued with undiminished intensity. We were, therefore, as I think, in the position described by Professor Dove, p. 289:—

"'Should the barometer oscillate, and yet the air remain at rest, the cause of the disturbance is at some distance. At times, in winter, the southerly current maintains its ground over a large area to such an extent that the air is delightfully mild, the barometer being low meanwhile. In this case there is somewhere in the neighbourhood a district where the barometer is high, and the weather very cold. *This cold air may then suddenly force its way into the rarefied air in its neighbourhood, as a storm, causing the barometer to rise rapidly.*'

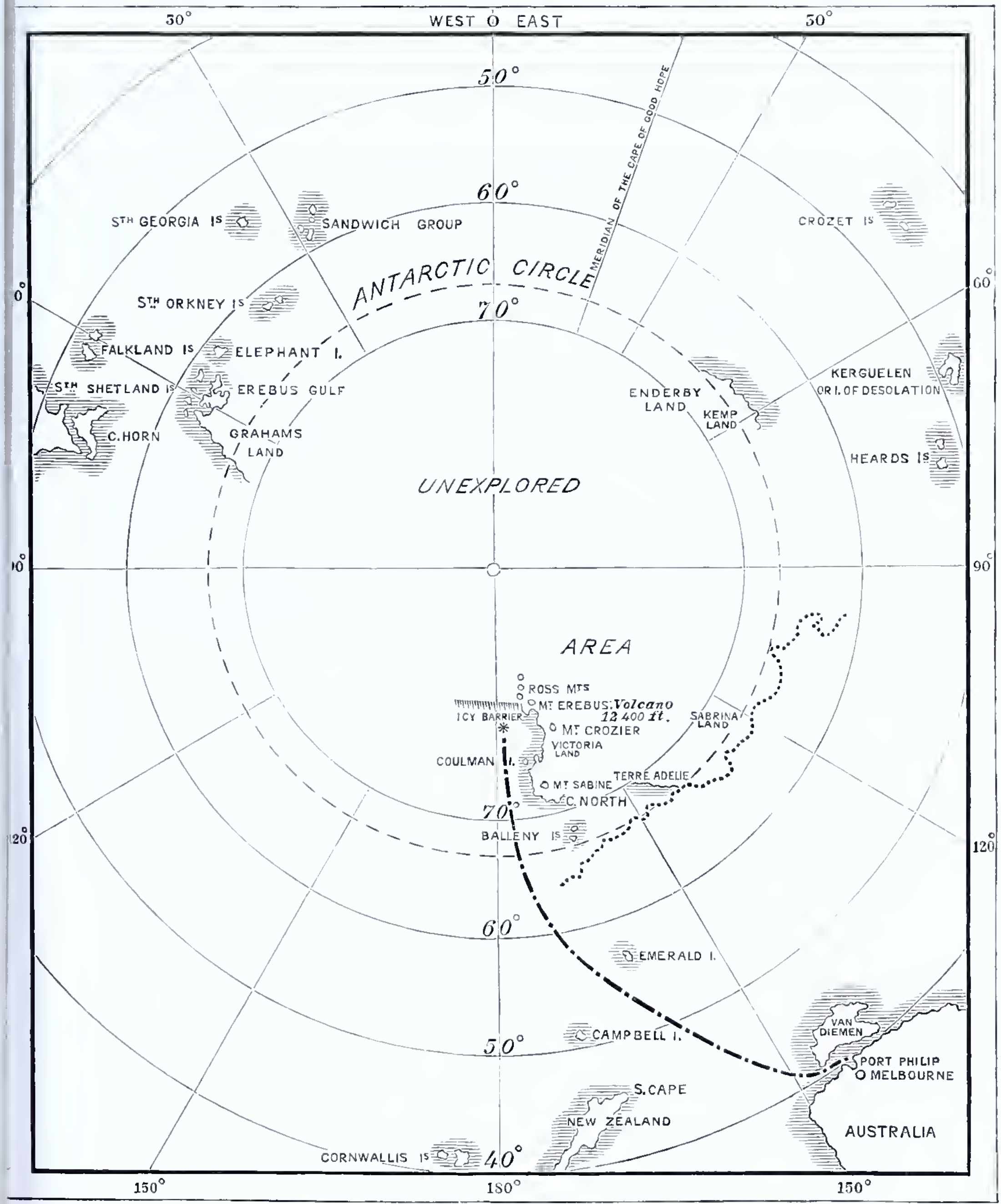
"I need not say that these views are an attempt to represent the published opinions of Professor Dove, under whom I have studied; and I cannot better conclude this letter than by giving you a confirmation of this theory which I have lately met with; it is from a paper by M. Spassky, entitled, 'Note sur la tempête d'hiver, &c., &c., entre le 9–11 Dec., 1850.' In explanation, I may say that there was on the 23rd of that month a barometric maximum in Europe, and a simultaneous minimum in America, followed by a violent snow-storm. This had been preceded by a minimum in Russia on the 6th, and a storm on the 9th. The narrative proceeds—'This storm lasted from thirty to forty-eight hours, between the 9th and 11th, without intermission. Before the gale it had been thawing; but the first gust caused the thermometer to fall 15° or 20° R. below Zero, so that persons who were out of doors fell dead, being lost in the driven snow, some close to their own doors. After the storm, 311 persons were found frozen to death in the Government of Kalonga, 140 in that of Tula, and 39 in the district of Kursk. It is probable that many more are as yet undiscovered, owing to the depth of snow. Houses were blown down, and even horses yoked to the sleighs were frozen to death. This atmospheric revolution was the result of the struggle between the two currents of air, by means of which Professor Dove's theory enables us to explain most atmospheric phenomena: and yet many physicists continue to dispute its truth, in the face of plain proofs like the above, which cannot be explained on any other hypothesis. In order to convince us that all the characteristic phenomena of the atmosphere were in exact accordance with Professor Dove's theory during this storm, we need only refer to the observations at Moscow. Before the 6th the Polar current prevailed there, N. wind, barometer 336·27 lines, and thermometer 14° 5 R. On the 6th the equatorial current appeared, barometer fell 15·53 lines before the 9th; the thermometer rose 12° 9, and the wind veered through S. to S. W. The polar current, having thus yielded to the first onset, collected its strength to force its opponent back. On the 9th there was a lull, followed by a north wind lasting up to the 11th, during which time the barometer rose 7·46 lines, and the thermometer fell 15° 4. On the evening of the 11th there was a fresh lull; and on the 12th the equatorial current set in again, as is shown by the wind getting round to S. W., the thermometer rising above Zero, and the barometer falling 6·06 lines.'

"Yours very sincerely,

"Robert H. Scott.

"*Rev. Professor Haughton.*"

ANTARCTIC DISCOVERIES



Lionel J. Fleming C.E.

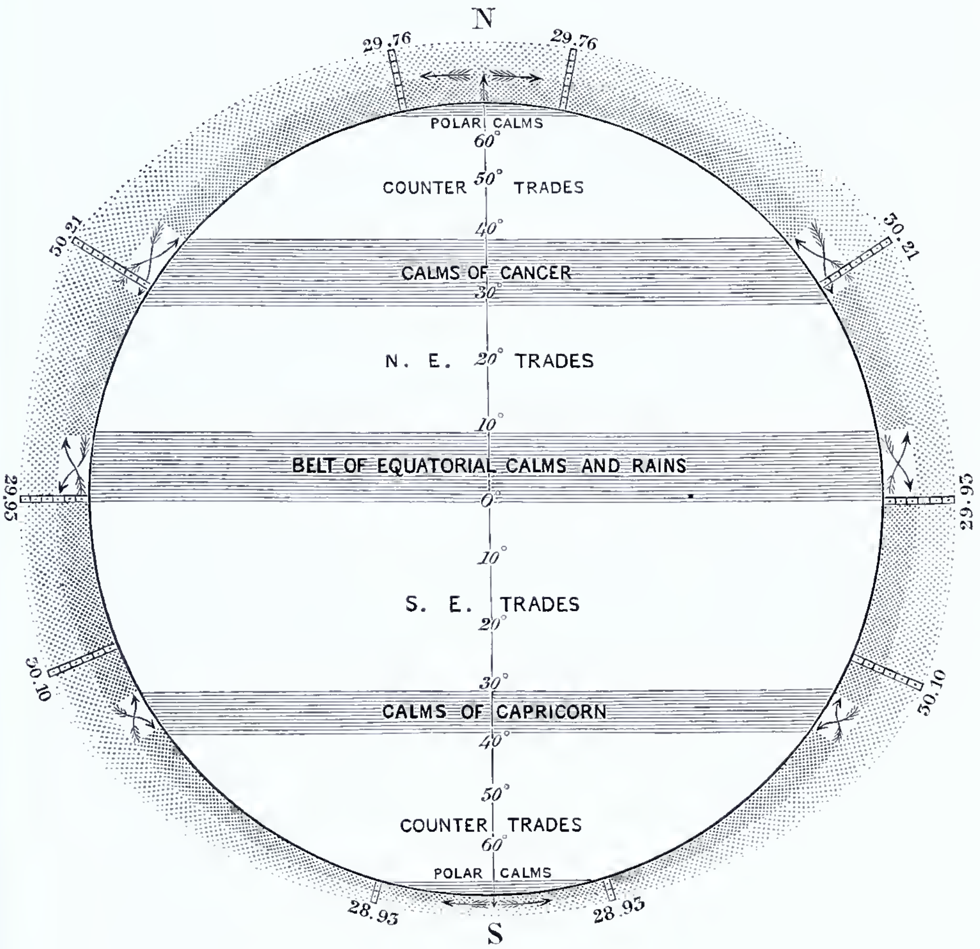
MAURY'S PROPOSED EXPLORATION ROUTE —·—·—·—·—·—

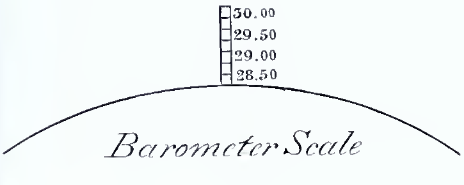
COAST DISCOVERED BY LIEUT WILKES U.S.N. ....

ROSS FURTHEST SOUTH 78°.10′. *

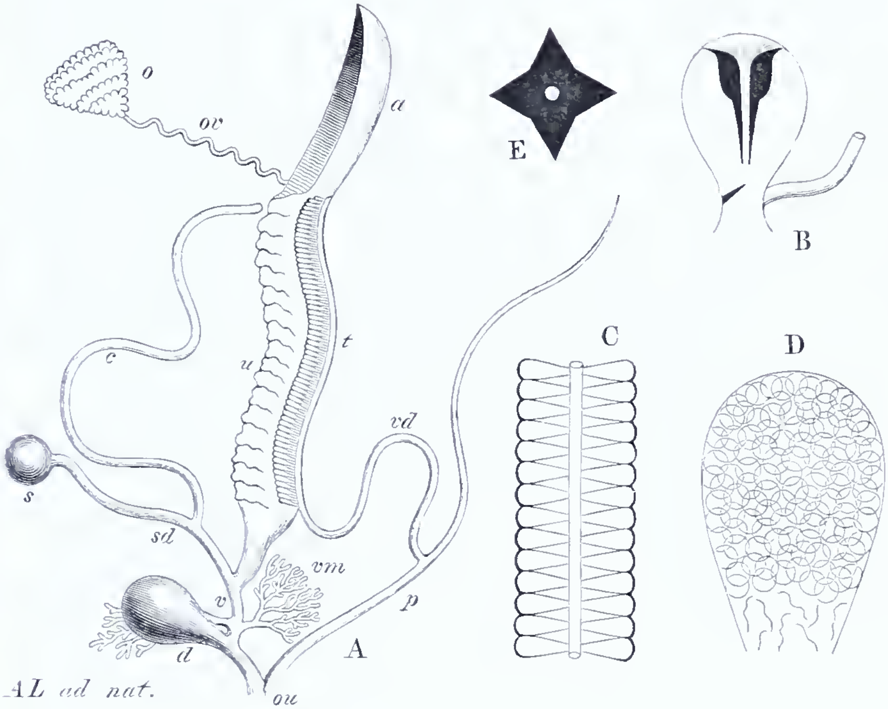
PROFILE OF THE ATMOSPHERE.

(FROM CAPTN M. F. MAURY. U.S.N.)

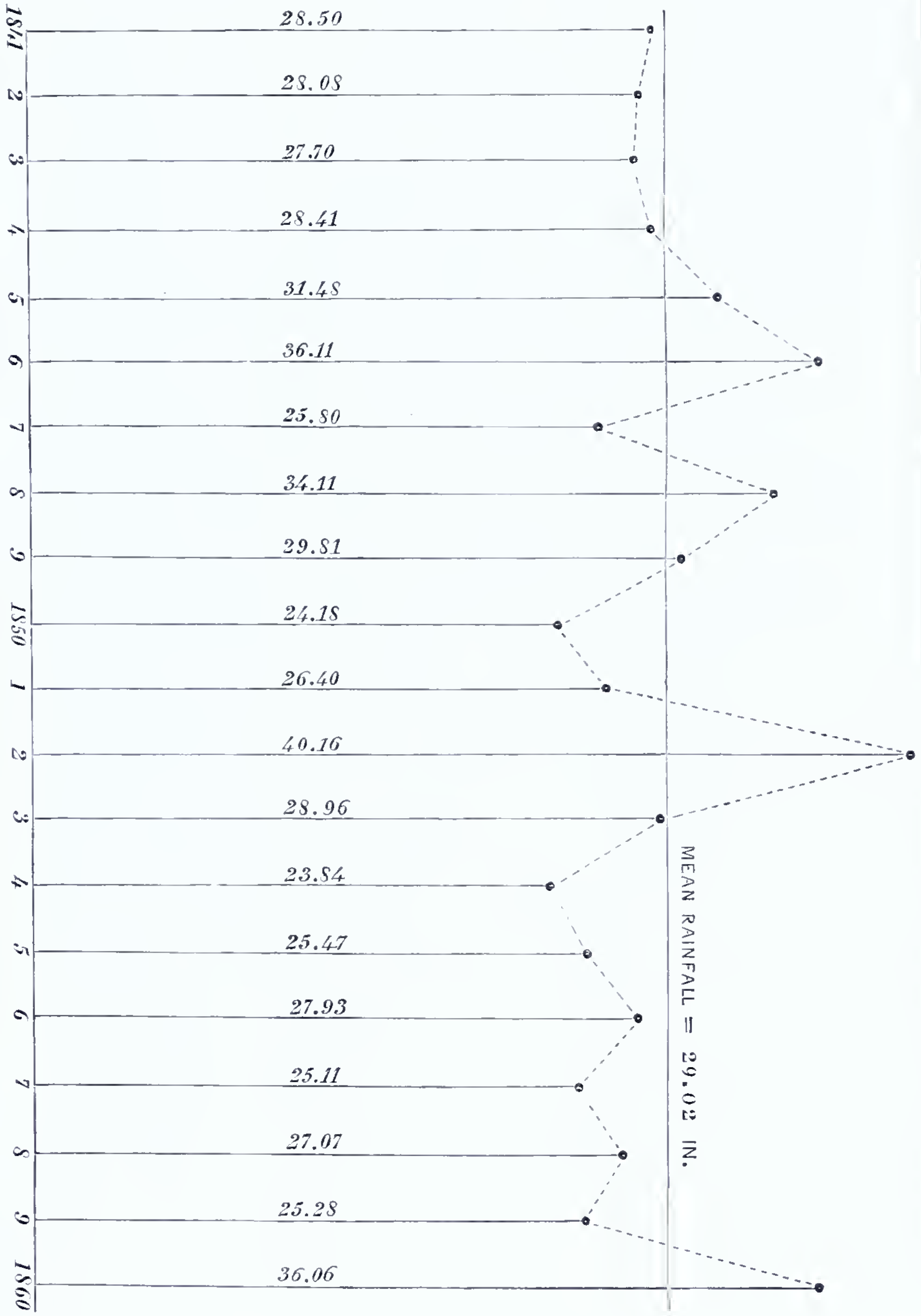


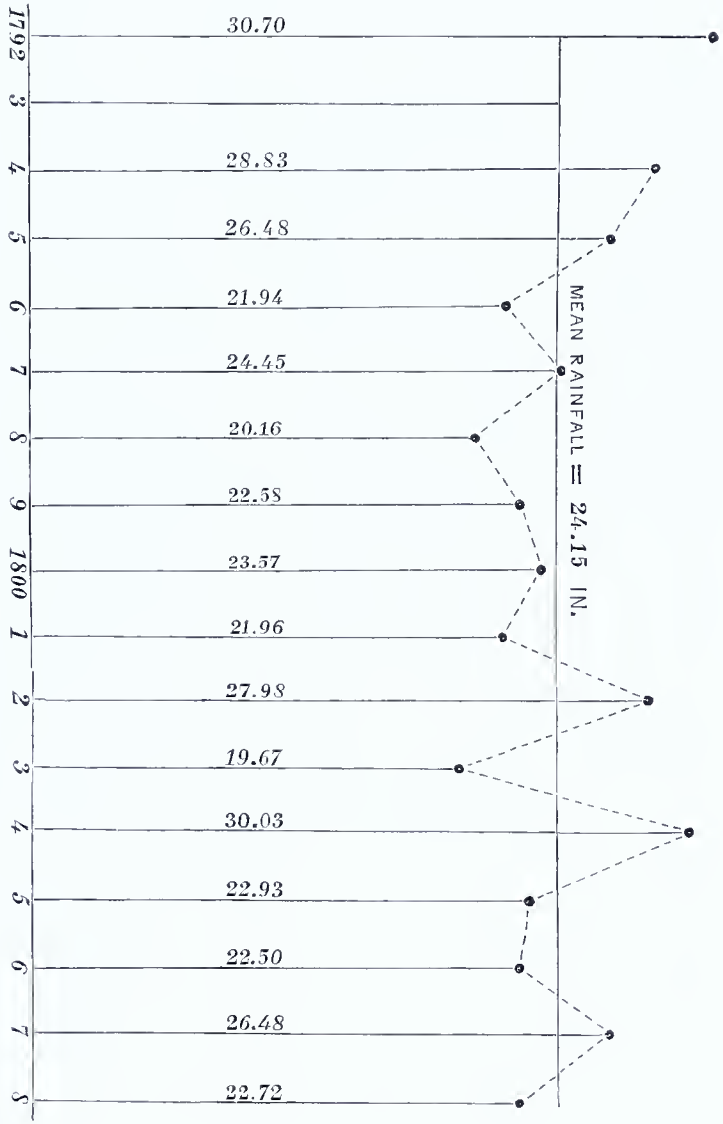


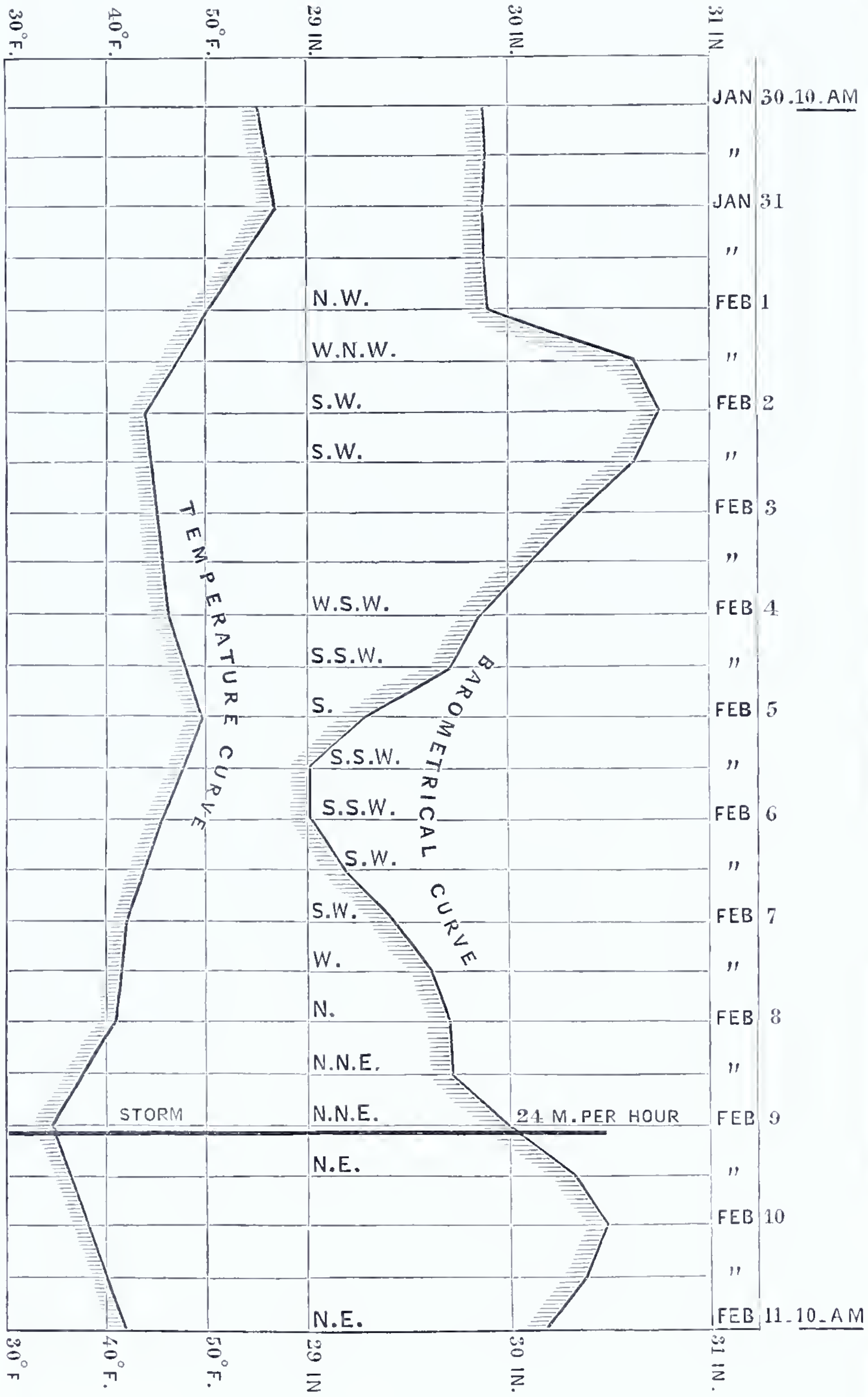
THE ARROWS MARK THE DIRECTION OF THE AERIAL CURRENTS – ASCENDING, DESCENDING & MEETING.



ANATOMY OF GENERATIVE SYSTEM OF HELIX ASPERSA AND HELIX HORTENSIS.


1841 28.50
2 28.08
3 27.70
4 28.41
5 31.48
6 36.11
7 25.80
8 34.11
9 29.81
1850 24.18
1 26.40
2 40.16
3 28.96
4 23.84
5 25.47
6 27.93
7 25.11
8 27.07
9 25.28
1860 36.06
MEAN RAINFALL = 29.02 IN.


1792
30.70
3
4
28.83
5
26.48
6
21.94
7
24.45
8
20.16
9
22.58
1800
23.57
1
21.96
2
27.98
3
19.67
4
30.03
5
22.93
6
22.50
7
26.48
8
22.72
MEAN RAINFALL = 24.15 IN.


30° F.
40° F.
50° F.
29 IN.
30 IN.
31 IN.
JAN 30. 10. AM
"
JAN 31
"
FEB 1
"
FEB 2
"
FEB 3
"
FEB 4
"
FEB 5
"
FEB 6
"
FEB 7
"
FEB 8
"
FEB 9
"
FEB 10
"
FEB 11. 10. AM
N.W.
W.N.W.
S.W.
S.W.
W.S.W.
S.S.W.
S.
S.S.W.
S.S.W.
S.W.
S.W.
W.
N.
N.N.E.
N.N.E.
N.E.
N.E.
TEMPERATURE CURVE
BAROMETRICAL CURVE
STORM
24 M. PER HOUR
30° F
40° F.
50° F.
29 IN
30 IN.
31 IN.